Analysis of diazinon and chlorpyrifos surface water monitoring and acute toxicity bioassay data, 1991 - 2001

F. Spurlock

January 2002

Environmental Hazards Assessment Program
Environmental Monitoring Branch
California Department of Pesticide Regulation
P.O. Box 4015 Sacramento CA 95812

EH01-01

CONTENTS

List of Figures

List of Figures (continued)

List of Tables

List of Appendices

I. INTRODUCTION

The organophosphate insecticides diazinon and chlorpyrifos have been the focus of numerous California surface water monitoring studies over the last decade. Among these are the Department of Pesticide Regulation's (DPR) dormant spray surface water monitoring studies conducted during the years 1997 - 2001(e.g., Bennett et al., 1998, Nordmark et al., 1998). These studies were conducted as part of DPR's dormant spray water quality program (http://www.cdpr.ca.gov/docs/surfwatr/programs.htm#dormant). One objective of DPR's five-year program is to evaluate concentration levels and trends for the two organophosphate pesticides diazinon and chlorpyrifos in California surface waters. This report analyzes DPR's 1997 - 2001 dormant spray monitoring data and data from several other previous studies. The analysis includes diazinon and chlorpyrifos concentration distributions, frequencies of detection, and co-occurrence frequencies of the two pesticides. Water quality criteria based on human health and aquatic toxicological levels are provided as benchmarks to interpret the data (Table 1).

In addition to chemical analysis, 96-hour *Ceriodaphnia dubia* acute aquatic toxicity tests were also conducted on several hundred samples over the last decade. Results from these toxicity tests are compared to the analytical chemistry results, with particular attention to the relationship between *C. dubia* acute toxicity assays and the analytical chemical data.

II. DATA OVERVIEW

The diazinon and chlorpyrifos sampling data analyzed here were compiled from 22 studies conducted during the years 1991-2001 by the Central Valley Regional Water Quality Control Board (CVRWQCB), the U.S. Geological Survey (USGS), Dow Agrosciences, and DPR (Appendix 1). The data represent all diazinon and chlorpyrifos monitoring data in DPR's surface water database (SWD) as of March 31, 2001, with the exception of data from

(1) urban stormwater drain sampling,
(2) studies with undocumented or unreported analytical methods,
(3) data based solely on ELISA (Enzyme-linked Immunosorbent Assay), and
(4) data reported to DPR that did not include accompanying QA/QC information.

Table 1. Freshwater criteria/benchmarks cited for comparison purposes.

DIAZINON			
Criterion ug L^{-1} (ppb)	**Type**	**Recurrence period**	**Source**
0.05	chronic aquatic tox	4-day average; not to be exceeded more than once in 3 years.	Calif. Dept. of Fish and Game, 2000
0.08	acute aquatic tox	1-hour average; not to be exceeded more than once in 3 years.	Calif. Dept. of Fish and Game, 2000
0.09	acute aquatic tox	1-hour average; not to be exceeded more than once in 3 years.	U.S. EPA, 1998, *draft*
0.436	96 hour *Ceriodaphnia dubia* LC_{50}	N/A	1998 Calif. Dept. Fish and Game
0.6	Drinking water health-based guidance level	N/A - Lifetime Health Action Advisory Level	U.S. EPA, 2000, Office of Water
CHLORPYRIFOS			
0.014	chronic aquatic tox	4-day average; not to be exceeded more than once in 3 years.	Calif. Dept. of Fish and Game, 2000
0.02	acute aquatic tox	1-hour average; not to be exceeded more than once in 3 years.	Calif. Dept. of Fish and Game, 2000
0.038	96 hour *Ceriodaphnia dubia* LC_{50}	N/A	Calif. Dept. of Fish and Game, 1999
20	Drinking water health-based guidance level	N/A - Lifetime Health Action Advisory Level	U.S. EPA, 2000, Office of Water

The ELISA analytical data were excluded because of recent data that suggested a systematic bias of ELISA, particularly in rain runoff water samples. A DPR-sponsored study is currently underway to fully investigate this question (DPR 2000b).

The concentration data analyzed in this report consisted of 3954 sampling events at 95 sites (diazinon), and 3901 sampling events at 82 sites (chlorpyrifos). Most samples were analyzed for both diazinon and chlorpyrifos (3716 samples). The 488 96-hour *C. dubia* acute toxicity tests were conducted as part of various studies between 1991 and 2000.

III. STATISTICAL CONSIDERATIONS

Several statistical issues were considered in analyzing the data; most of these issues center around questions of independence, randomness, and representativeness of the data. The following overview is based largely on diazinon data; the chlorpyrifos data set characteristics are similar due to the extensive overlap in sampling.

Geographical distribution of sampling

For the purposes of this report, the sampling sites were operationally classified into “river” and “tributary” sampling sites (Table 2a - d). Using this classification scheme, there were 1824 tributary samples (46 percent of total samples) and 2130 river samples (54 percent) for diazinon. The data are geographically biased. Five sampling sites constitute more than 60% of all data (Figure 1): the San Joaquin River near Vernalis (river, site 3917, 783 samples), Sacramento River near the I street bridge in Sacramento (river, site 3413, 437 samples), and 3 individual sites on Orestimba creek (tributaries, sites 5026, 5027, 5028; 335, 341, and 556 samples, respectively). The chlorpyrifos data is similarly biased (Table 2c, 2d). Overall the river data are dominated by two sites: the San Joaquin River near Vernalis (38% of the river samples) and the Sacramento River near the I street bridge (21% of the river samples), while three Orestimba Creek sites constitute 70% of all tributary samples.

While the Sacramento River I street bridge site probably reflects agricultural and urban inputs to surface water, most other sampling sites - especially tributaries - are distant from

Table 2a. Diazinon sampling locations, river/tributary designations, and number of samples by month.

		MONTH												TOTAL	
	locat														
riv/trib	**code**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**SAMPLES**	**description**
river	3917	133	153	92	73	46	43	45	46	41	42	43	58	815	San Joaquin River near Vernalis
trib	5028	77	92	56	46	17	40	39	38	36	37	34	44	556	Orestimba Creek at River Road (trib. to SJR)
river	3413	47	63	47	39	24	23	24	34	34	37	33	32	437	Sacramento River at I Street Bridge
trib	5027	31	28	31	30	9	30	31	31	30	31	28	31	341	Orestimba Creek above Crow Creek Drain
trib	5026	27	28	31	30	9	30	31	29	30	31	29	30	335	Orestimba Creek at State Hwy. 33 Bridge
river	3418	50	48	17									12	127	Sacramento R at Alamar Marina Dock, 9 mi below confluence w/ Feather R.
river	5015	18	18	21	22	7	4	4	4	4	2	1	6	111	San Joaquin River at Laird Park
river	2406	8	11	6	10	7	7	5	6	4	6	4	4	78	Merced River at Hatfield State Park
trib	5113	29	32	9									6	76	Wadsworth Canal at Franklin Rd
trib	5104	27	16	6									8	57	Sutter Bypass at Karnak Pumping Sta.
river	5105	5	4	4	4	5	4	4	5	4	5	4	4	52	Sacramento River 2.5 mi downstream of confluence w/ Feather
river	2407	8	16	9	5	2	3	1	2	2	1	1	1	51	Merced River at River Road Bridge near Newman
trib	2413	4	5	5	11	6	6	3	3	2	1	1		47	Salt Slough (trib. to SJR) at Highway 165
trib	5106	12	24	7									2	45	Sutter Bypass at Kirkville Road
trib	5702	12	15	2	3	2	1	2	1	1	1	2	2	44	Colusa Basin Drain at Rd. 99E, near Knights Landing
river	5107	8	7	3	3	2	2	2	2	2	2	2	2	37	Feather River near Nicolaus at Hwy 99 Bridge
river	4903	1				4	4	5	4	4	4	5	4	35	Russian River at Midway Beach
trib	5014	3	4	5	5	6	3	1	1	1	2		2	33	Ingram/Hospital Creek (trib. to SJR)
trib	3415	3	3	3	3	3	2	2	2	2	2	3	2	30	Arcade Creek at Norwood
trib	5018	3	4	3	6	6	3	1	1	1			2	30	Del Puerto Creek (trib. to SJR)
trib	5024	5	6	3	6	3	3	1	1				1	29	Turlock Irrig. Dist. Drain #5
river	2703	3					1	2	5	4	4	5	4	28	Salinas River at Gonzales River Rd. Bridge
river	5029	2	2	1	5	4	4	4	4	2				28	San Joaquin River at Hills Ferry
river	2702	2	4	4	4	5	3	2	1					25	Salinas River at Chualar River Rd. Bridge
river	3405	1	2	2	3	3	3	3	2	1	1	2	2	25	Sacramento River at Freeport/Sump 3
river	5701	6	12	3									3	24	Sacramento River at Bryte
trib	5103	12	11											23	Sacramento Slough near Karnak
river	3918	3	4		5	3	4	1	1		1			22	Stanislaus River at Caswell State Park
trib	5025	2	3	3	4	6	4							22	Spanish Grant Drain (trib. to SJR)
river	604	8	12											20	Sacramento River at Colusa, 60 ft. downstream from highway Bridge
river	5016	3	4		4	4	3	1	1					20	Tuolumne River at Shiloh
river	5023	2	2		4			4	4	2				18	San Joaquin River at West Main
trib	2402	2	4		2	4	3	1				1		17	Turlock Irrig. Drain #6, 200 yds W of Central Ave (trib to SJR)
trib	5019	2	3	5	2	4	1							17	Turlock Irrig. Dist. Drain #3 at Jennings Rd Bridge
trib	5115	7	10											17	Butte Slough at Lower Pass Road
river	4902	3	4	4	4	1								16	Russian River at Hacienda Bridge
river	5007	5	9	2										16	Tuolumne River at Modesto
river	2701	1	1	1	1	2	1		2		2	1		12	Salinas Lagoon
river	2409	2	2		4			1	1					10	San Joaquin River at Fremont Ford
river	2411	2	2		4			1	1					10	San Joaquin River near Stevinson
river	5001	5	5											10	Stanislaus River at Ripon
river	5002	2	2		4			1	1					10	San Joaquin River at Maze Blvd.
trib	2408	2	2		4			1	1					10	Newman Wasteway (trib. to SJR)
trib	2412	2	2		4			1	1					10	Mud Slough (trib. to SJR)
river	5803	6	3											9	Feather River at Yuba City
trib	401	2	7											9	Main Drainage Canal at Colusa Hwy (trib to Cherokee Canal)

	MONTH													TOTAL	
	locat														
riv/trib	**code**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**SAMPLES**	**description**
trib	5110	2	7											9	Sacramento Outfall at DWR PP on Sacramento Road
trib	5802	2	7											9	Jack Slough at Marysville
trib	2410	2	2		4									8	Los Banos Creek (trib. to SJR)
river	5017		3	4										7	Tuolumne River at Carpenter Rd Bridge
trib	5111	2	5											7	Obanion Outfall at DWR PP on Obanion Road
river	1306		1							1	2	2		6	Alamo River at Harris Street Bridge
river	1301									1	2	1	1	5	Alamo River at Outlet
river	1302									1	2	1	1	5	Alamo River at Albright Road (Nectarine Drain Area
river	1309	1	1								1	1	1	5	Alamo River at Holtville
river	1321	1	1								1	1	1	5	Alamo River at All American Canal
trib	3909	2	3											5	Lone Tree Creek at Austin Rd trib to French Camp Slough
trib	5109	1	4											5	Gilsizer Slough at G. Washington Rd (trib to Butte Slough)
river	1304									1	1	1	1	4	Alamo River downstream of Rose Drain
river	1307		1								1	1	1	4	Alamo River at Worthington Road
river	1308	1	1								1	1		4	Alamo River at Holtville WTP
river	1320	1	1								1	1		4	Alamo River downstream of Verde Drain
trib	5008		2	2										4	Dry Creek at Gallo Rd near Modesto
river	1303									1	1	1		3	Alamo River at Shank Road (Magnolia Drain Area
river	1305									1	1	1		3	Alamo River downstream of Holtville Main Drain
river	3905			2	1									3	Paradise Cut north of MacArthur Rd and Delta Ave (north of Tracy, inside Delta
river	3907		3											3	San Joaquin River at Bowman Rd
river	3919	1	2											3	Mokelumne River at New Hope Rd Bridge (in Delta)
river	5020		2	1										3	Tuolumne River at Mitchell Rd Bridge
river	5804	2	1											3	Yuba River at Marysville
trib	601		3											3	Clarks Ditch, trib. to Colusa Basin Drain
trib	2405	1	2											3	Livingston Spillway (trib. to SJR)
trib	3903	1	2											3	French Camp Slough at Manthey Bridge
trib	3910			2	1									3	Bishop Tract Main Drain (in Delta)
trib	4806			2	1									3	Ulatis Creek at Brown Road
trib	5004		2	1										3	Dry Creek at Claus Rd, Modesto
river	2401	1	1											2	Merced River at Oakdale Road
river	3908		2											2	Old River off Cohen Road
river	5201		2											2	Sacramento River at Vina at Woodson Bridge
river	5801	2												2	Bear River at Berry Road
trib	2403		2											2	Stevinson Spillway (trib. to SJR)
trib	2404		2											2	Highline Spillway (trib. to SJR)
trib	5805	2												2	Honcut Creek at Chandler Road
river	704		1											1	Marsh Creek at Cypress Rd Bridge (trib to western Delta)
river	1101		1											1	Sacramento River at Butte City at Hwy 162 Bridge
river	3906			1										1	Old River at Tracy Road (inside Delta)
river	3916				1									1	Bishop Cut at Eight Mile Rd (in Delta)
river	5013		1											1	Tuolumne River at Roberts Ferry Bridge
river	5112		1											1	Feather River near Olivehurst at Lee Rd and Garden Hwy
trib	402		1											1	Sacramento River at Hamilton at Hwy 32 Bridge
trib	4805		1											1	Ledgewood Creek in City of Fairfield
trib	5010		1											1	Dry Creek at Leask Bridge nr Waterford
trib	5011		1											1	Oakdale Irr Dist at Ellenwood Rd nr Waterford
trib	5012		1											1	Turlock Irr Dist Hickman Spillway
trib	5022		1											1	Turlock Irr Dist Ceres Main Spillway

Table 2b. Diazinon sampling locations, river/tributary designations, and number of samples by year.

	location	Year of sampling												site
riv/trib	**code**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**TOTAL**	**description**
river	3917	173	183	230	75	8	3	24	30	30	30	29	815	San Joaquin River near Vernalis
trib	5028	8	16	50			254	150	18	20	20	20	556	Orestimba Creek at River Road (trib. to SJR)
river	3413	58	140	173	66								437	Sacramento River at I Street Bridge
trib	5027						221	120					341	Orestimba Creek above Crow Creek Drain
trib	5026						219	116					335	Orestimba Creek at State Hwy. 33 Bridge
river	3418							3	30	30	33	31	127	Sacramento R at Alamar Marina Dock, 9 mi below confluence w/ Feather R.
river	5015	30	65	16									111	San Joaquin River at Laird Park
river	2406	4	16	2	28	28							78	Merced River at Hatfield State Park
trib	5113				10				2	20	22	22	76	Wadsworth Canal at Franklin Rd
trib	5104						2	8	3	8	14	22	57	Sutter Bypass at Karnak Pumping Sta.
river	5105			7	45								52	Sacramento River 2.5 mi downstream of confluence w/ Feather
river	2407			40	11								51	Merced River at River Road Bridge near Newman
trib	2413	3	16	28									47	Salt Slough (trib. to SJR) at Highway 165
trib	5106							8	17	12	8		45	Sutter Bypass at Kirkville Road
trib	5702				23		2	15	4				44	Colusa Basin Drain at Rd. 99E, near Knights Landing
river	5107				10		11	12	4				37	Feather River near Nicolaus at Hwy 99 Bridge
river	4903				20	15							35	Russian River at Midway Beach
trib	5014	12	19	2									33	Ingram/Hospital Creek (trib. to SJR)
trib	5018	10	18	2									30	Del Puerto Creek (trib. to SJR)
trib	3415						2	24	4				30	Arcade Creek at Norwood
trib	5024	7	20	2									29	Turlock Irrig. Dist. Drain #5
river	5029	4	22	2									28	San Joaquin River at Hills Ferry
river	2703				22	6							28	Salinas River at Gonzales River Rd. Bridge
river	3405						2	16	7				25	Sacramento River at Freeport/Sump 3
river	2702					25							25	Salinas River at Chualar River Rd. Bridge
river	5701						3	21					24	Sacramento River at Bryte
trib	5103				23								23	Sacramento Slough near Karnak
trib	5025	6	14	2									22	Spanish Grant Drain (trib. to SJR)
river	3918	6	13	2	1								22	Stanislaus River at Caswell State Park
river	5016	2	15	2	1								20	Tuolumne River at Shiloh
river	604				20								20	Sacramento River at Colusa, 60 ft. downstream from highway Bridge
river	5023	3	13	2									18	San Joaquin River at West Main
trib	5115				17								17	Butte Slough at Lower Pass Road
trib	5019	3	14										17	Turlock Irrig. Dist. Drain #3 at Jennings Rd Bridge
trib	2402	3	14										17	Turlock Irrig. Drain #6, 200 yds W of Central Ave (trib to SJR)
river	5007				11	5							16	Tuolumne River at Modesto
river	4902					16							16	Russian River at Hacienda Bridge
river	2701				4	8							12	Salinas Lagoon
river	5002	3	5	2									10	San Joaquin River at Maze Blvd.
river	5001				10								10	Stanislaus River at Ripon
trib	2412	3	5	2									10	Mud Slough (trib. to SJR)
river	2411	3	5	2									10	San Joaquin River near Stevinson
river	2409	3	5	2									10	San Joaquin River at Fremont Ford
trib	2408	3	5	2									10	Newman Wasteway (trib. to SJR)
river	5803				9								9	Feather River at Yuba City
trib	5802				9								9	Jack Slough at Marysville

location					Year of sampling									site
riv/trib	code	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL	description
trib	5110				9								9	Sacramento Outfall at DWR PP on Sacramento Road
trib	401				9								9	Main Drainage Canal at Colusa Hwy (trib to Cherokee Canal)
trib	2410	3	3	2									8	Los Banos Creek (trib. to SJR)
trib	5111				7								7	Obanion Outfall at DWR PP on Obanion Road
river	5017					7							7	Tuolumne River at Carpenter Rd Bridge
river	1306			5	1								6	Alamo River at Harris Street Bridge
trib	5109		5										5	Gilsizer Slough at G. Washington Rd (trib to Butte Slough)
trib	3909		5										5	Lone Tree Creek at Austin Rd trib to French Camp Slough
river	1321			3	2								5	Alamo River at All American Canal
river	1309			3	2								5	Alamo River at Holtville
river	1302			5									5	Alamo River at Albright Road (Nectarine Drain Area
river	1301			5									5	Alamo River at Outlet
trib	5008					4							4	Dry Creek at Gallo Rd near Modesto
river	1320			2	2								4	Alamo River downstream of Verde Drain
river	1308			2	2								4	Alamo River at Holtville WTP
river	1307			3	1								4	Alamo River at Worthington Road
river	1304			4									4	Alamo River downstream of Rose Drain
river	5804				3								3	Yuba River at Marysville
river	5020					3							3	Tuolumne River at Mitchell Rd Bridge
trib	5004					3							3	Dry Creek at Claus Rd, Modesto
trib	4806		3										3	Ulatis Creek at Brown Road
river	3919		3										3	Mokelumne River at New Hope Rd Bridge (in Delta)
trib	3910		3										3	Bishop Tract Main Drain (in Delta)
river	3907		3										3	San Joaquin River at Bowman Rd
river	3905		3										3	Paradise Cut north of MacArthur Rd and Delta Ave (north of Tracy, inside Delta
trib	3903		3										3	French Camp Slough at Manthey Bridge
trib	2405			2	1								3	Livingston Spillway (trib. to SJR)
river	1305			3									3	Alamo River downstream of Holtville Main Drain
river	1303			3									3	Alamo River at Shank Road (Magnolia Drain Area
trib	601		3										3	Clarks Ditch, trib. to Colusa Basin Drain
trib	5805				2								2	Honcut Creek at Chandler Road
river	5801				2								2	Bear River at Berry Road
river	5201				2								2	Sacramento River at Vina at Woodson Bridge
river	3908		2										2	Old River off Cohen Road
trib	2404			1	1								2	Highline Spillway (trib. to SJR)
trib	2403			1	1								2	Stevinson Spillway (trib. to SJR)
river	2401			2									2	Merced River at Oakdale Road
river	5112		1										1	Feather River near Olivehurst at Lee Rd and Garden Hwy
trib	5022					1							1	Turlock Irr Dist Ceres Main Spillway
river	5013					1							1	Tuolumne River at Roberts Ferry Bridge
trib	5012					1							1	Turlock Irr Dist Hickman Spillway
trib	5011					1							1	Oakdale Irr Dist at Ellenwood Rd nr Waterford
trib	5010					1							1	Dry Creek at Leask Bridge nr Waterford
trib	4805		1										1	Ledgewood Creek in City of Fairfield
river	3916		1										1	Bishop Cut at Eight Mile Rd (in Delta)
river	3906		1										1	Old River at Tracy Road (inside Delta)
river	1101				1								1	Sacramento River at Butte City at Hwy 162 Bridge
river	704		1										1	Marsh Creek at Cypress Rd Bridge (trib to western Delta)
trib	5022		1										1	Turlock Irr Dist Ceres Main Spillway

Table 2c. Chlorpyrifos sampling locations, river/tributary designations, and number of samples by month.

	MONTH													TOTAL	
	locat														
riv/trib	code	1	2	3	4	5	6	7	8	9	10	11	12	SAMPLES	description
Riv	3917	132	152	92	73	46	43	45	46	41	42	43	58	813	San Joaquin River near Vernalis
Trib	5028	80	92	56	46	41	40	39	38	36	37	35	45	585	Orestimba Creek at River Road (trib. to SJR)
Riv	3413	47	63	47	39	24	23	24	34	34	37	33	32	437	Sacramento River at I Street Bridge
Trib	5027	31	28	31	30	30	30	31	31	30	31	30	31	364	Orestimba Creek above Crow Creek Drain
Trib	5026	31	28	31	30	30	30	31	30	30	31	30	31	363	Orestimba Creek at State Hwy. 33 Bridge
Riv	5015	18	18	21	22	7	4	9	13	8	2	1	6	129	San Joaquin River at Laird Park
Riv	3418	50	48	17									12	127	Sacramento R. at Alamar Marina Dock, 9 mi below confluence of Feather R.
Riv	2406	8	11	6	10	8	7	5	6	4	6	4	4	79	Merced River at Hatfield State Park
Trib	5113	27	24	9									6	66	Wadsworth Canal at Franklin Rd
Riv	5105	5	4	4	4	5	4	4	5	4	5	4	4	52	Sacramento River 2.5 mi downstream of confluence w/ Feather
Trib	5104	27	16	6									2	51	Sutter Bypass at Karnak Pumping Sta.
Trib	2413	4	5	5	11	6	6	3	2	2	1	1		46	Salt Slough (trib. to SJR) at Highway 165
Riv	5029	2	2	1	5	4	4	9	13	6				46	San Joaquin River at Hills Ferry
Trib	5106	12	24	7									2	45	Sutter Bypass at Kirkville Road
Riv	2407	3	10	9	5	2	3	1	2	2	1	1	1	40	Merced River at River Road Bridge near Newman
Riv	5023	2	2		4			9	13	6				36	San Joaquin River at West Main
Riv	4903	1				4	4	5	4	4	4	5	4	35	Russian River at Midway Beach
Trib	5014	3	4	5	5	6	3	1	1	1	2		2	33	Ingram/Hospital Creek (trib. to SJR)
Trib	3415	3	3	3	3	3	2	2	2	2	2	3	2	30	Arcade Creek at Norwood
Trib	5018	3	4	3	6	6	3	1	1	1			2	30	Del Puerto Creek (trib. to SJR)
Trib	5024	5	6	3	6	3	3	1	1				1	29	Turlock Irrig. Dist. Drain #5
Riv	2703	3					1	2	5	4	4	5	4	28	Salinas River at Gonzales River Rd. Bridge
Riv	5107	2	3	3	3	2	2	2	2	2	2	2	2	27	Feather River near Nicolaus at Hwy 99 Bridge
Riv	2702	2	4	4	4	5	3	2	1					25	Salinas River at Chualar River Rd. Bridge
Riv	3405	1	2	2	2	3	3	3	2	1	1	2	2	24	Sacramento River at Freeport/Sump 3
Riv	5701	6	12	3									3	24	Sacramento River at Bryte
Trib	5702	3	4	2	3	2	1	2	1	1	1	2	2	24	Colusa Basin Drain at Rd. 99E, near Knights Landing
Trib	5025	2	3	3	4	6	4							22	Spanish Grant Drain (trib. to SJR)
Riv	3918	3	3		5	3	4	1	1		1			21	Stanislaus River at Caswell State Park
Riv	5016	3	3		4	4	3	1	1					19	Tuolumne River at Shiloh
Trib	2402	2	4		2	4	3	1				1		17	Turlock Irrig. Drain #6, 200 yds W of Central Ave (trib to SJR)
Trib	5019	2	3	5	2	4	1							17	Turlock Irrig. Dist. Drain #3 at Jennings Rd Bridge
Riv	4902	3	4	4	4	1								16	Russian River at Hacienda Bridge
Riv	5007	5	9	2										16	Tuolumne River at Modesto
Riv	2701	1	1	1	1	2	1		2		2	1		12	Salinas Lagoon
Trib	2408	2	2		4			1	1					10	Newman Wasteway (trib. to SJR)
Riv	2409	2	2		4			1	1					10	San Joaquin River at Fremont Ford
Riv	2411	2	2		4			1	1					10	San Joaquin River near Stevinson
Trib	2412	2	2		4			1	1					10	Mud Slough (trib. to SJR)
Riv	5002	2	2		4			1	1					10	San Joaquin River at Maze Blvd.
Trib	2410	2	2		4									8	Los Banos Creek (trib. to SJR)
Riv	5017		3	4										7	Tuolumne River at Carpenter Rd Bridge
Riv	1306		1							1	2	2		6	Alamo River at Harris Street Bridge
Riv	1301									1	2	1	1	5	Alamo River at Outlet
Riv	1302									1	2	1	1	5	Alamo River at Albright Road (Nectarine Drain Area)
Riv	1309	1	1								1	1	1	5	Alamo River at Holtville

	MONTH													**TOTAL**	
	locat														
riv/trib	**code**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**SAMPLES**	**description**
Riv	1321	1	1								1	1	1	5	Alamo River at All American Canal
Trib	3909	2	3											5	Lone Tree Creek at Austin Rd trib to French Camp Slough
Trib	5109	1	4											5	Gilsizer Slough at G. Washington Rd (trib to Butte Slough)
Riv	1304									1	1	1	1	4	Alamo River downstream of Rose Drain
Riv	1307		1								1	1	1	4	Alamo River at Worthington Road
Riv	1308	1	1								1	1		4	Alamo River at Holtville WTP
Riv	1320	1	1								1	1		4	Alamo River downstream of Verde Drain
Trib	5008		2	2										4	Dry Creek at Gallo Rd near Modesto
Trib	601		1								1		1	3	Clarks Ditch, trib. to Colusa Basin Drain
Riv	1303									1	1	1		3	Alamo River at Shank Road (Magnolia Drain Area)
Riv	1305									1	1	1		3	Alamo River downstream of Holtville Main Drain
Trib	3903	1	2											3	French Camp Slough at Manthey Bridge
Riv	3905			2	1									3	Paradise Cut north of MacArthur Rd and Delta Ave (no. of Tracy, in Delta)
Riv	3907		3											3	San Joaquin River at Bowman Rd
Trib	3910			2	1									3	Bishop Tract Main Drain (in Delta)
Riv	3919	1	2											3	Mokelumne River at New Hope Rd Bridge (in Delta)
Trib	4806			2	1									3	Ulatis Creek at Brown Road
Trib	5004		2	1										3	Dry Creek at Claus Rd, Modesto
Riv	5020		2	1										3	Tuolumne River at Mitchell Rd Bridge
Riv	2401	1	1											2	Merced River at Oakdale Road
Trib	2405	1	1											2	Livingston Spillway (trib. to SJR)
Riv	3908		2											2	Old River off Cohen Road
Riv	704										1			1	Marsh Creek at Cypress Rd Bridge (trib to western Delta)
Trib	2403		1											1	Stevinson Spillway (trib. to SJR)
Trib	2404		1											1	Highline Spillway (trib. to SJR)
Riv	3906			1										1	Old River at Tracy Road (inside Delta)
Riv	3916				1									1	Bishop Cut at Eight Mile Rd (in Delta)
Trib	4805		1											1	Ledgewood Creek in City of Fairfield
Trib	5010		1											1	Dry Creek at Leask Bridge nr Waterford
Trib	5011		1											1	Oakdale Irr Dist at Ellenwood Rd nr Waterford
Trib	5012		1											1	Turlock Irr Dist Hickman Spillway
Riv	5013		1											1	Tuolumne River at Roberts Ferry Bridge
Trib	5022		1											1	Turlock Irr Dist Ceres Main Spillway
Trib	5110		1											1	Sacramento Outfall at DWR PP on Sacramento Road
Riv	5112		1											1	Feather River near Olivehurst at Lee Rd and Garden Hwy

Table 2d. Chlorpyrifos sampling locations, river/tributary designations, and number of samples by year.

	location				Year of sampling									site
riv/trib	code	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL	description
Riv	3917	173	182	230	75	8	3	24	30	29	30	29	813	San Joaquin River near Vernalis
Trib	5028	8	16	50			280	153	18	20	20	20	585	Orestimba Creek at River Road (trib. to SJR)
Riv	3413	58	140	173	66								437	Sacramento River at I Street Bridge
Trib	5027						244	120					364	Orestimba Creek above Crow Creek Drain
Trib	5026						243	120					363	Orestimba Creek at State Hwy. 33 Bridge
Riv	5015	48	65	16									129	San Joaquin River at Laird Park
Riv	3418							3	30	30	33	31	127	Sacramento R. at Alamar Marina Dock, 9 mi below confluence of Feather R.
Riv	2406	4	16	2	28	29							79	Merced River at Hatfield State Park
Trib	5113								2	20	22	22	66	Wadsworth Canal at Franklin Rd
Trib	5104						2	8	3	8	14	22	57	Sutter Bypass at Karnak Pumping Sta.
Riv	5105			7	45								52	Sacramento River 2.5 mi downstream of confluence w/ Feather
Trib	2413	3	15	28									46	Salt Slough (trib. to SJR) at Highway 165
Riv	5029	22	22	2									46	San Joaquin River at Hills Ferry
Trib	5106							8	17	12	8		45	Sutter Bypass at Kirkville Road
Riv	2407			40									40	Merced River at River Road Bridge near Newman
Riv	5023	21	13	2									36	San Joaquin River at West Main
Riv	4903				20	15							35	Russian River at Midway Beach
Trib	5014	12	19	2									33	Ingram/Hospital Creek (trib. to SJR)
Trib	3415						2	24	4				30	Arcade Creek at Norwood
Trib	5018	10	18	2									30	Del Puerto Creek (trib. to SJR)
Trib	5024	7	20	2									29	Turlock Irrig. Dist. Drain #5
Riv	2703				22	6							28	Salinas River at Gonzales River Rd. Bridge
Riv	5107						11	12	4				27	Feather River near Nicolaus at Hwy 99 Bridge
Riv	2702					25							25	Salinas River at Chualar River Rd. Bridge
Riv	3405						2	15	7				24	Sacramento River at Freeport/Sump 3
Riv	5701						3	21					24	Sacramento River at Bryte
Trib	5702				3		2	15	4				24	Colusa Basin Drain at Rd. 99E, near Knights Landing
Trib	5025	6	14	2									22	Spanish Grant Drain (trib. to SJR)
Riv	3918	6	13	2									21	Stanislaus River at Caswell State Park
Riv	5016	2	15	2									19	Tuolumne River at Shiloh
Trib	2402	3	14										17	Turlock Irrig. Drain #6, 200 yds W of Central Ave (trib to SJR)
Trib	5019	3	14										17	Turlock Irrig. Dist. Drain #3 at Jennings Rd Bridge
Riv	4902					16							16	Russian River at Hacienda Bridge
Riv	5007				11	5							16	Tuolumne River at Modesto
Riv	2701				4	8							12	Salinas Lagoon
Trib	2408	3	5	2									10	Newman Wasteway (trib. to SJR)
Riv	2409	3	5	2									10	San Joaquin River at Fremont Ford
Riv	2411	3	5	2									10	San Joaquin River near Stevinson
Trib	2412	3	5	2									10	Mud Slough (trib. to SJR)
Riv	5002	3	5	2									10	San Joaquin River at Maze Blvd.
Trib	2410	3	3	2									8	Los Banos Creek (trib. to SJR)
Riv	5017					7							7	Tuolumne River at Carpenter Rd Bridge
Riv	1306			5	1								6	Alamo River at Harris Street Bridge
Riv	1301			5									5	Alamo River at Outlet
Riv	1302			5									5	Alamo River at Albright Road (Nectarine Drain Area)

location					Year of sampling									site
riv/trib	**code**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**TOTAL**	**description**
Riv	1309			3	2								5	Alamo River at Holtville
Riv	1321			3	2								5	Alamo River at All American Canal
Trib	3909		5										5	Lone Tree Creek at Austin Rd trib to French Camp Slough
Trib	5109		5										5	Gilsizer Slough at G. Washington Rd (trib to Butte Slough)
Riv	1304			4									4	Alamo River downstream of Rose Drain
Riv	1307			3	1								4	Alamo River at Worthington Road
Riv	1308			2	2								4	Alamo River at Holtville WTP
Riv	1320			2	2								4	Alamo River downstream of Verde Drain
Trib	5008					4							4	Dry Creek at Gallo Rd near Modesto
Trib	601									2	1		3	Clarks Ditch, trib. to Colusa Basin Drain
Riv	1303			3									3	Alamo River at Shank Road (Magnolia Drain Area)
Riv	1305			3									3	Alamo River downstream of Holtville Main Drain
Trib	3903		3										3	French Camp Slough at Manthey Bridge
Riv	3905		3										3	Paradise Cut north of MacArthur Rd and Delta Ave (no. of Tracy, in Delta)
Riv	3907		3										3	San Joaquin River at Bowman Rd
Trib	3910		3										3	Bishop Tract Main Drain (in Delta)
Riv	3919		3										3	Mokelumne River at New Hope Rd Bridge (in Delta)
Trib	4806		3										3	Ulatis Creek at Brown Road
Trib	5004					3							3	Dry Creek at Claus Rd, Modesto
Riv	5020					3							3	Tuolumne River at Mitchell Rd Bridge
Riv	2401			2									2	Merced River at Oakdale Road
Trib	2405			2									2	Livingston Spillway (trib. to SJR)
Riv	3908		2										2	Old River off Cohen Road
Riv	704									1			1	Marsh Creek at Cypress Rd Bridge (trib to western Delta)
Trib	2403			1									1	Stevinson Spillway (trib. to SJR)
Trib	2404			1									1	Highline Spillway (trib. to SJR)
Riv	3906		1										1	Old River at Tracy Road (inside Delta)
Riv	3916		1										1	Bishop Cut at Eight Mile Rd (in Delta)
Trib	4805		1										1	Ledgewood Creek in City of Fairfield
Trib	5010					1							1	Dry Creek at Leask Bridge nr Waterford
Trib	5011					1							1	Oakdale Irr Dist at Ellenwood Rd nr Waterford
Trib	5012					1							1	Turlock Irr Dist Hickman Spillway
Riv	5013					1							1	Tuolumne River at Roberts Ferry Bridge
Trib	5022					1							1	Turlock Irr Dist Ceres Main Spillway
Trib	5110				1								1	Sacramento Outfall at DWR PP on Sacramento Road
Riv	5112		1										1	Feather River near Olivehurst at Lee Rd and Garden Hwy

discharge locations of California's largest population centers, so the data primarily reflect agricultural as opposed to urban diazinon and chlorpyrifos inputs. There are some exceptions, most notably Arcade Creek, an urban tributary in Sacramento County with numerous detections of both diazinon and chlorpyrifos (site 3415).

Temporal distribution of sampling

The tributary and river data were collected in various years between 1991 and 2001, and sampling was distributed over different months of the year depending on the objectives of the specific monitoring study. The distribution of sampling over both years and months was biased. For example, 84 percent of the river samples were collected between the years 1991 and 1995, inclusive (Figure 2). In addition, the most frequent sampling occurred during January and February when rainfall driven off-site movement of diazinon and chlorpyrifos in surface water runoff was most likely to occur (Figure 3, Table 2). Consequently more than forty five percent of samples were collected during the months of January – March, as opposed to the expected twenty five percent had the sampling been random throughout the year.

Sampling frequency

Various approaches to sample timing and frequency were taken in different studies. Sampling events in some studies were initiated when storm events occurred (e.g., studies 10, 39, 47 and others, appendix 1). Many other studies utilized a fixed sampling schedule (e.g., studies 32, 33, 37, 38, 41, 45 and others, appendix 1). One likely consequence of the former "storm chasing"-type sampling is higher detection frequencies and concentration centiles relative to those studies with a fixed sampling schedule.

Sampling method

A variety of sampling methods were used to collect samples in the different studies. These include grab sampling from the bank, depth-integrated sampling, hourly composite 24 hour sampling, and equal-width increment sampling among others. There is only very limited data suitable for comparing the effect of various sampling methods in the particular water bodies sampled. It is probable that effects are important at certain locations depending on site-specific characteristics including flow conditions.

Correlation/autocorrelation

Correlation of data between sites. A majority of the tributary samples (68 percent) were from Orestimba Creek and most of the Orestimba data were collected in a single study (Study 45, Appendix 1). Study 45 was a one year study that included daily sampling at each of three tributary sites from May 1996 to April 1997. Consequently, study 45 comprises 58 percent of all tributary data. The three Orestimba sampling sites fall within a 10 kilometer reach of Orestimba Creek, and both the diazinon and chlorpyrifos study 45 data display significant site - to - site correlations (Figure 4). While the correlations reflect the spatial and temporal proximity of sampling events, they probably also indicate that common regional mechanisms of pesticide off-site movement to surface water are operative, such as off-site movement in rainfall runoff. As a result, simultaneous excursions above any particular benchmark level at the 3 sites are not independent. Detections at the three Orestimba Creek sites during the same or proximate days are often measuring a concentration signal or "pulse" as it moves down the watershed, so that many exceedances observed at the three sites are "regional" in nature. This is probably a general characteristic of other groups of proximate sites. Consequently, when enumerating extreme events - such as exceedances – over counting can occur.

Autocorrelation of data at a single site. Similar to the spatial correlation of data at proximate sites, temporally proximate data at some individual sites were autocorrelated (e.g., Figures 5 and 6). Autocorrelation means, for example, that low concentrations at a site tend to be associated with low concentrations on following or preceding day(s). Similarly, high concentrations tend to be associated with high concentrations on preceding or subsequent days. The autocorrelation for chlorpyrifos at State Highway 33, Orestimba Creek (5/23/96 - 4/30/97) is significantly different than zero for lag times of up to 6 days, so that across the entire year's sampling, concentrations in samples collected up to 6 days apart (or less, Figure 5) are significantly correlated. This result indicates that concentration pulses at the site *tend* to occur over characteristic time scales on the order of days as opposed to, for instance, hours. One consequence of autocorrelation is that high concentrations tend to occur in groups so that high concentration measurements on adjacent or proximate days are not, in general, independent. This is probably a general characteristic - at least to some degree - of data from many sites, and means that exceedances on adjacent or proximate days are not, in general, independent events. Similar to site-to-site correlations discussed above, autocorrelated data tend to "over count" independent exceedance events.

Instantaneous concentrations and toxicity criteria

Toxicity criteria (e.g., Table 1) are generally characterized by concentration and duration of exposure (e.g., *C. dubia* 96 hour LC_{50}). Some illustrative comparisons are made in this report between "instantaneous" concentration distributions and toxicity criteria. These comparisons are not quantitative because instantaneous concentrations do not consider duration of exposure. For example, it could be argued that an instantaneous concentration that exceeds a 96 hour LC_{50} may not actually result in lethality if the concentration represents a "very brief" concentration spike. Consequently, the toxicity criteria presented here are general benchmarks for evaluating relative concentration levels. However, the significant autocorrelations observed at certain sites (discussed above) suggest that many single high concentration measurements probably do represent extended duration excursions above criterion levels.

LOQ (limit of quantitation)

Various terms are used to describe the lower limit of detectable concentration of a chemical analyte, including reporting limit, method detection limit, and lowest detectable concentration. These are generically referred to as "limit of quantitation" (LOQ) in the SWD. The LOQ may be considered as roughly analogous to analytical method detection limits. The LOQs for both diazinon and chlorpyrifos ranged over 2 orders of magnitude among the different studies considered here (Table 3).

Detection frequency is inversely related to LOQ. Consequently detection frequencies of different groups of data cannot be meaningfully compared without accounting for the differences in LOQ between the groups. Figures 7 and 8 illustrate the effect of LOQ on diazinon and chlorpyrifos detection frequencies at tributary and river sites. The "concentration censored" data (Figures 7b, 8b) provide a common basis for comparing detection frequencies at the two types of sites, and were obtained by defining all detections below 0.04 ug/L as non-detections.

Table 3. Number of samples by limit of quantitation (LOQ)

DIAZINON	
LOQ (ug L^{-1} , ppb)	**number of samples**
0.001	1063
0.002	260
0.006	1
0.008	110
0.01	248
0.017	1
0.018	1
0.019	164
0.023	24
0.024	1
0.028	27
0.031	345
0.04	424
0.05	514
0.1	48
CHLORPYRIFOS	
0.001	1143
0.004	234
0.005	4
0.007	1
0.01	248
0.012	1
0.025	27
0.028	457
0.035	345
0.04	393
0.044	273
0.05	567
0.1	48

At various locations in this report concentration censored data is discussed. In ALL cases where censored data is discussed, a censoring cutoff, or threshold of 0.04 ug/L was applied and the discussion explicitly states that the data are concentration censored. The choice of 0.04 ug/L as a censoring threshold for both diazinon and chlorpyrifos was based on the need for an effective censoring scheme to compare groups of data across months, years, and/or types of water bodies, while also minimizing loss of concentration information in the censoring procedure, particularly at levels of regulatory interest. One difficulty arises in that there were many samples with an actual LOQ greater than the censoring threshold of 0.04 ug/L (Table 3). Consequently in those cases the number of samples with concentration higher than the censoring threshold but less than the actual LOQ are unknown; the censored detection frequency for such data is unavoidably biased downward. These data include both chlorpyrifos and diazinon data (48 samples, 27 detections) collected from the Alamo River in 1993 - 1994 where the actual LOQ was = 0.1 ug/L. Those Alamo River samples displayed relatively high frequencies of detection, effectively reducing the bias effect. The remainder of samples with actual LOQ greater than the censoring threshold of 0.04 ug/L were from the San Joaquin Valley. The San Joaquin data so affected include 417 river samples and 97 tributary samples, all collected during the years 1991 – 1995. Consequently the censored detection frequencies for 1991 – 1995 data are biased downward.

Summary of major statistical issues and consequences

In summary, a very large body of California organophosphate monitoring data is examined here. The data are temporally and spatially nonrandom. Consequently statistical measures of the **overall data set** – including various concentration centiles and detection frequencies - are only descriptive of this particular data set, and are inappropriate for <u>quantitative</u> inferences of median concentrations and associated confidence limits of historical diazinon and chlorpyrifos concentrations in California waters.

On the other hand, the data do indicate general characteristics of diazinon and chlorpyrifos concentrations, including the relative magnitudes, locations, and seasonality of diazinon and chlorpyrifos concentrations in some water bodies. In addition, certain limited subsets of the data are suitable for statistical analysis.

IV. OVERVIEW OF DIAZINON AND CHLORPYRIFOS USE DATA 1991 - 2000

Most of the surface water monitoring data was collected in the San Joaquin and Sacramento River basins. The following overview is based on 1991 - 2000 total reported pesticide use from DPR's pesticide use database for those counties that contribute agricultural surface water runoff to the two watersheds. These are Butte, Colusa, Glenn, Placer, Sacramento, Sutter, Tehama, Yolo, and Yuba Counties (Sacramento River Basin), and Fresno, Madera, Merced, San Joaquin, and Stanislaus Counties (San Joaquin Basin). These counties represented a total of 1.6 million acres of harvested cropland (Sacramento River basin) and 2.7 million acres of harvested cropland (San Joaquin River basin) in 1997 (Table 4).

The annual use of diazinon in San Joaquin basin counties has been 1.5 - 2.5 times greater than in the Sacramento basin, but the relative difference for chlorpyrifos was much greater, ranging up to more than 5 times as much applied annually in the San Joaquin basin than in the Sacramento basin. Overall, use of chlorpyrifos was much greater than diazinon in both basins throughout the 1990s, but annual applications of both organophosphates have steadily decreased since the mid- to latter part of the decade. (Figure 9).

The winter (Dec - Mar) use of diazinon during the 1990s was primarily in fruit orchard crops and nut orchard crops (Figure 10). For diazinon, fruit orchard crops include prunes, peaches, nectarines, and plums. Diazinon applications to nut orchard crops are almost exclusively to almonds, with a very small amount of reported applications to walnuts. Principal row crop diazinon applications include lettuce, broccoli, tomatoes, corn, melons, and sugarbeets. Overall, diazinon applications to both fruit and nut orchards have decreased since the early 1990s (Figure 10). This reduction corresponds to a reduction in winter diazinon use since these applications occurr primarily in winter (Figure 11).

Although annual use of chlorpyrifos has decreased, there has been no consistent trend in winter use over the last decade. Selected winter uses have actually increased in recent years (e.g., vines and fruit orchard crops, Figure 10). Fruit orchard applications of chlorpyrifos include peaches, apples, nectarine, plums, and prunes. Similar to diazinon, chlorpyrifos applications to nut orchards are primarily in almonds. A five year trend of decreasing wintertime chlorpyrifos applications to alfalfa began in 1997. This decrease, coupled with increasing applications to fruit orchards, resulted in fruit orchards surpassing alfalfa applications as the largest winter use in the year 2000.

Table 4. Acres harvested cropland in Sacramento and San Joaquin River Basin Counties, 1997. Source: USDA National Agricultural Statistics Service, *http://www.nass.usda.gov/census/census97/highlights/ca/ca.htm* (verified 5/24/01)

County	Basin	Harvested Acres
Butte	Sac	222,209
Colusa	Sac	287,630
Glenn	Sac	212,848
Placer	Sac	28,431
Sacramento	Sac	120,220
Sutter	Sac	266,399
Tehama	Sac	62,038
Yolo	Sac	324,291
Yuba	Sac	79,586
Fresno	SJ	1,157,357
Madera	SJ	294,706
Merced	SJ	434,074
San Joaquin	SJ	498,985
Stanislaus	SJ	315,978

Based on recent use data, diazinon applications are greatest during the month of January when applications occur in both fruit and nut orchard crops (Figure 11). Chlorpyrifos displays a distinctly different use pattern, with the greatest use occurring in cotton during the months of August and September (Figure 12). Other substantial chlorpyrifos applications occur May through August in nut crops, and March in alfalfa.

V. ANALYTICAL CHEMICAL RESULTS

All data

Detection frequencies Across all data, chlorpyrifos and diazinon detections were more frequent in tributary samples than river samples (Table 5; Figures 7, 8). While diazinon tributary detection frequencies based on the “raw” (uncensored) data are almost uniformly high - exceeding 60 percent in all months except December - the censored detection frequencies show that the higher concentration diazinon tributary detections (>0.04 ug/L) were most frequent during the months of Jan-May and August (Figure 7b). Although Orestimba Creek dominates the tributary data, a similar pattern was observed in the remainder of tributary sites. The seasonal distribution of detections is a reflection of the seasonal use pattern of diazinon and the seasonal distribution of rainfall.

Diazinon river detections were somewhat similar to tributaries: most higher concentration diazinon detections occurred during the winter rainy season of January - March, with some higher concentration detections also in the month of August. There were no diazinon detections above the censoring limit of 0.04 ug/L during the months of September - November in the Sacramento or San Joaquin basin rivers; twenty-four of the twenty-five censored detections during these months were from the Alamo River, Imperial County, and one was from the Russian River in Sonoma County.

Unlike diazinon, chlorpyrifos detections during January and February were infrequent in both rivers and tributaries relative to other times of the year. Tributary detections of chlorpyrifos were highest (35 – 40 percent) during March - May based on the censored data (Figure 8b), although the censored tributary detection frequencies still ranged from about 10 to 20 percent during the summer months of June – September. Censored chlorpyrifos river detection frequencies were relatively low compared to diazinon, with the highest censored detection frequencies of around 3 - 7 percent occurring during September - November. Similar to the diazinon river results for September - November, none of the fall chlorpyrifos river detections occurred in the San Joaquin or Sacramento Valley. All of the fall censored chlorpyrifos river

Table 5a. River/tributary detection frequencies by month (1991 - 2001)
UNCENSORED DATA

DIAZINON		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
tributary	**no. detects**	178	267	137	134	63	109	103	101	95	83	71	31	1372
	no. samples	279	347	176	162	75	126	114	109	103	105	98	130	1824
	pct. detects	64%	77%	78%	83%	84%	87%	90%	93%	92%	79%	72%	24%	75%
river	**no. detects**	157	245	71	19	19	12	4	18	8	14	10	2	579
	no. samples	344	416	224	200	119	109	110	126	110	121	113	138	2130
	pct. detects	46%	59%	32%	10%	16%	11%	4%	14%	7%	12%	9%	1%	27%
Total	**no. detects**	335	512	208	153	82	121	107	119	103	97	81	33	1951
	no. samples	623	763	400	362	194	235	224	235	213	226	211	268	3954
	pct. detects	54%	67%	52%	42%	42%	51%	48%	51%	48%	43%	38%	12%	49%

CHLORPYRIFOS		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
tributary	**no. detects**	15	45	120	128	130	106	102	100	100	83	52	9	990
	no. samples	246	277	176	162	141	126	114	109	103	106	102	133	1795
	pct. detects	6%	16%	68%	79%	92%	84%	89%	92%	97%	78%	51%	7%	55%
river	**no. detects**	13	25	20	20	15	9	1	2	4	8	3	0	120
	no. samples	309	378	224	199	120	109	125	153	122	122	113	135	2112
	pct. detects	4%	7%	9%	10%	13%	8%	1%	1%	3%	7%	3%	0%	6%
Total	**no. detects**	28	70	140	148	145	115	103	102	104	91	55	9	1110
	no. samples	555	655	400	361	261	235	239	262	225	228	215	268	3907
	pct. detects	5%	11%	35%	41%	56%	49%	43%	39%	46%	40%	26%	3%	28%

Table 5b. River/tributary detection frequencies by month (1991 - 2001) concentration censored data: censoring threshold = 0.04 ug/L

DIAZINON		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
tributary	no. detects	115	197	61	60	26	24	21	37	9	5	3	4	562
	no. samples	279	347	176	162	75	126	114	109	103	105	98	130	1824
	pct. detects	41%	57%	35%	37%	35%	19%	18%	34%	9%	5%	3%	3%	31%
river	no. detects	125	200	37	6	1	1	1	16	6	12	8	1	414
	no. samples	344	416	224	200	119	109	110	126	110	121	113	138	2130
	pct. detects	36%	48%	17%	3%	1%	1%	1%	13%	5%	10%	7%	1%	19%
Total	no. detects	240	397	98	66	27	25	22	53	15	17	11	5	976
	no. samples	623	763	400	362	194	235	224	235	213	226	211	268	3954
	pct. detects	39%	52%	25%	18%	14%	11%	10%	23%	7%	8%	5%	2%	25%

CHLORPYRIFOS		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
tributary	no. detects	6	15	64	56	57	12	15	20	19	0	0	0	264
	no. samples	246	277	176	162	141	126	114	109	103	106	102	133	1795
	pct. detects	2%	5%	36%	35%	40%	10%	13%	18%	18%	0%	0%	0%	15%
river	no. detects	3	12	2	5	0	0	0	1	4	8	3	0	38
	no. samples	309	378	224	199	120	109	125	153	122	122	113	135	2112
	pct. detects	1%	3%	1%	3%	0%	0%	0%	1%	3%	7%	3%	0%	2%
Total	no. detects	9	27	66	61	57	12	15	21	23	8	3	0	302
	no. samples	555	655	400	361	261	235	239	262	225	228	215	268	3907
	pct. detects	2%	4%	17%	17%	22%	5%	6%	8%	10%	4%	1%	0%	8%

detections were from various sampling locations in the Alamo River, Imperial Valley during 1993. There has been no sampling at the Alamo River reported to the SWD since that time.

Although diazinon was commonly detected in river sites of the Sacramento Valley, there were no reported chlorpyrifos detections at any river sites in the Sacramento Valley. Sacramento Valley river sites that have been sampled for chlorpyrifos include the Sacramento, Feather, and Bear rivers. There have been, however, reported detections of chlorpyrifos in several San Joaquin Valley rivers, including the San Joaquin, Tuolumne, Merced and Stanislaus rivers. Most sampling for chlorpyrifos at river sites was conducted in the early 1990's, and the majority of chlorpyrifos detections in rivers occurred during the years 1991 - 1993. This includes the San Joaquin Valley rivers mentioned above. The most recent detection of chlorpyrifos in a river site reported in the SWD was in 1995. However, sampling for chlorpyrifos at river sites since 1995 has been much less frequent than in the early 1990s, and much of the recent sampling was conducted with a somewhat higher LOQ of 0.04 ug/L as compared to the early to 1990s.

Overall, chlorpyrifos was detected much less frequently than diazinon in river samples in spite of it's greater use. In most cases the pesticides were analyzed with approximately equal LOQs, so that LOQ is not a factor in comparing their relative detection frequencies. Diazinon is generally less persistent than chlorpyrifos (e.g., median aerobic soil half-life of 30 vs. 86 days), so that other factors must account for diazinon's higher detection frequency in rivers. Two of these are (i) diazinon's lower soil sorption coefficient relative to chlorpyrifos (median K_{OC} of 1200 vs. 6100 for chlorpyrifos), and (ii) seasonal use patterns of the two pesticides. The effect of lower K_{OC} is to possibly increase dissolved runoff concentrations which may allow generally greater off-site movement in water. However, the most important factor is probably the greater use of diazinon during the rainy season when river sampling frequency has been highest (Figure 3).

Concentration distributions Concentrations of both diazinon and chlorpyrifos were higher in tributary samples than in river samples (Figures 13, 14). Most of the highest concentrations were measured in the early 1990s, corresponding to the period when sampling was most frequent. For example, the period 1992 - 1994 included 99 of the 100 highest diazinon river concentrations (> 0.17ug/L) reported (Appendix 2). Many of these detections were in the San Joaquin River at various sites (especially Vernalis), the Sacramento River, and the Alamo River in Imperial County. There have been few recent detections of diazinon greater than 0.1 ug/L in river sites, but the number of sampled river sites and sampling frequency has been very low in recent years (Table 2).

In contrast to rivers, high diazinon tributary concentrations have occurred in both the early 1990s and in recent years. While many of the 100 highest diazinon tributary detections (> 0.5 ug/L) occurred during 1992-1994, 40 percent also occurred during the period 1996 – 2001 (appendix 3) . These “high” detections occurred at several tributary locations, including the three Orestimba Creek sites (sites 5026-5028), Wadsworth Canal (site 5113), Gilsizer Slough (site 5109), Main Drainage Canal (site 401) and others.

As previously discussed, there have been no river detections of chlorpyrifos since 1995, probably a result of (i) decreased sampling in recent years, (ii) the higher LOQ in recent sampling, and (iii) possibly reduced chlorpyrifos use. Across all river data, the highest concentrations reported have been for the Alamo River; 15 of the highest 20 chlorpyrifos river samples ever reported were from Alamo River sampling in 1993 (Appendix 4).

A large majority of chlorpyrifos detections in tributary sites (82 percent of censored tributary detections) were the result of the intensive sampling of Orestimba Creek during 1996 – 1997 in study 45. The large fraction of chlorpyrifos tributary detections contributed by the Orestimba Creek data partially reflects the large overall number of Orestimba Creek sampling events (68 percent of all tributary data). Study 45 accounts for more than ninety of the top 100 chlorpyrifos tributary detections (Appendix 5). These detections occurred during the months of March - September. While high chlorpyrifos concentrations have been measured at Orestimba Creek, Orestimba is grossly over-represented in the tributary data. It is not obvious whether Orestimba Creek is generally representative of other San Joaquin Valley tributaries with regard to chlorpyrifos presence and/or concentrations. Other tributary sites where chlorpyrifos has been detected include Arcade Creek (an urban stream in the

Sacramento Valley), the Colusa Basin Drain, and numerous drains/tributaries in the San Joaquin Valley: Salt Slough, Del Puerto Creek, Ingram/Hospital Creek, Spanish Grant Drain, and Turlock Irrigation District Drains #3, 5, and 6.

Exceedance frequencies Tributary and river exceedance frequencies of diazinon and chlorpyrifos water quality benchmarks are shown in Table 6. The exceedance frequencies were determined from the sampling data, and so are subject to the same statistical limitations concerning lack of independence, temporal and spatial randomness, and representativeness.

Table 6. Exceedance frequencies (percent) of selected diazinon and chlorpyrifos benchmark criteria [A]

DIAZINON	**Criterion**	**Exceedance Frequency (%)**		
Criterion - source	**ug L^{-1}**	**all data**	**river**	**tributary**
chronic aquatic tox - CDFG 2000	0.05	21.7	16.9	27.2
acute aquatic tox - CDFG 2000	0.08	15.8	10.9	21.6
Ceriodaphnia dubia LC_{50} - CDFG 1998	0.436	3.5	1.2	6.2
Drinking water Lifetime Health Action Advisory Level - U.S. EPA	0.600	2.4	0.8	4.4
CHLORPYRIFOS	**Criterion**	**Exceedance Frequency (%)**		
Criterion - source	**ug L^{-1}**	**all data**	**river**	**tributary**
chronic aquatic tox - CDFG 2000	0.014	16.8	2.9	32.9
acute aquatic tox CDFG 2000	0.02	13.5	2.6	26.2
Ceriodaphnia dubia LC_{50} - CDFG 1999	0.038	8.1	1.8	15.4
Drinking water Lifetime Health Action Advisory Level - U.S. EPA	20	0	0	0

[A] Chronic and acute aquatic toxiciology criteria comparisons based on concentration comparisons only; duration of exposure not considered in comparisons.

The diazinon exceedance frequencies in Table 6 are relatively unaffected by LOQ because they are determined by data at the upper end of the detected diazinon concentration spectrum; these concentrations are typically much greater than the LOQ. However, chlorpyrifos is more toxic than diazinon to aquatic benchmark species so that chlorpyrifos water quality criteria are correspondingly lower than diazinon. Consequently some of the chlorpyrifos benchmark criteria are either comparable to or lower than chlorpyrifos LOQs. For example, much of the recent chlorpyrifos monitoring data was obtained using an LOQ of 0.04 ug/L, as compared to the DFG acute and chronic criteria of 0.02 and 0.014 ug/L, respectively. In general, exceedances of a criterion are under-counted whenever a significant portion of data is based on an LOQ greater than that criterion.

DPR's dormant spray monitoring program (1997 - 2001)

Diazinon The most recent data in the SWD are from DPR's San Joaquin and Sacramento River dormant season monitoring studies (32, 33, 37, 38, 57, 58, 62, 63, 70, 71, appendix 1). In these studies selected tributary and main stem river sites were sampled during the annual dormant spray application time window of Dec - Mar (Figure 15). The studies were conducted during the five winter dormant spray application seasons of 1997 - 2001.

In DPR's Sacramento River dormant spray monitoring studies (studies 33, 37, 57, 63, 71, appendix 1) diazinon was found more frequently and at higher concentrations in tributaries than in the Sacramento River sites. The Sacramento River tributary sites were Wadsworth Canal (site 5113) and the Sutter Bypass (sites 5104 and 5106), both located in Sutter County. Diazinon detection frequencies for these sites were 74 percent and 34 percent for Wadsworth and the Sutter Bypass, respectively (LOQ = 0.04). The highest diazinon concentrations were observed at Wadsworth Canal (Figure 15). Diazinon concentrations at Wadsworth ranged up to 2.74 ug/L with 11 samples (17 percent) exceeding 0.5 ug/L during the monitoring period at Wadsworth of 1998 – 2001. Concentrations were lower in the Sutter Bypass; the maximum concentration observed there was 0.132 ug/L. In the two Sacramento River sites (sites 3418 and 5701), the detection frequency over the five years of sampling was 13 percent; the maximum diazinon concentration was 0.171 ug/L in a 1998 sample taken approximately 9 miles below the confluence of the Feather and Sacramento Rivers at the Alamar Marina.

In DPR's San Joaquin River dormant studies (32, 38, 58, 62, 70), Orestimba Creek at River Road was the only tributary sampled, while river samples were collected at the San Joaquin River near Vernalis. The maximum diazinon concentrations at these two sites during the five years of sampling were similar: 0.161 and 0.144 ug/L for Orestimba Creek and Vernalis, respectively. Detection frequencies at Vernalis and Orestimba Creek, River Road, were also comparable at 13 and 12 percent, respectively (LOQ = 0.04 ug/L).

C*hlorpyrifos* Five hundred sixty samples from 7 sites in the Sacramento and San Joaquin basin were collected during DPR's 1997 - 2001 dormant spray monitoring program. Chlorpyrifos was detected in one sample (concentration = 0.093 ug/L, LOQ = 0.04 ug/L) in January 1998 at Orestimba Creek, River Road. As discussed previously, some of the chlorpyrifos benchmark criteria are lower than the actual LOQ of 0.04 ug/L used during DPR's 1997-2001 dormant spray monitoring studies.

Exceedance frequencies DPR's recent monitoring (1997 - 2001) yielded slightly lower winter season river and tributary exceedance frequencies (Table 7) for the diazinon DFG acute criterion and the *C. dubia* LC_{50} benchmark value as compared to the overall 1991-2001 data (Table 6). The DPR dormant spray monitoring data were collected during the winter rainy season when high diazinon concentrations are expected to be most frequent. Although the diazinon exceedance frequencies in DPR's studies were lower relative to the early 1990s, most of the DPR sampling sites had no or very limited sampling in the early- to mid-90s. Consequently early- to mid-90s monitoring data and DPR's recent dormant spray data are not directly comparable.

Figure 16 illustrates the highest concentrations measured in the Sacramento and San Joaquin Rivers during the five-year dormant spray studies. There were no observed excursions above the *C. dubia* LC_{50} during DPR's studies except at Wadsworth Canal. At Wadsworth numerous exceedances of the *C. dubia* LC_{50} have been observed since sampling at Wadsworth began in dormant spray winter season 1998 - 1999 (Figure 17). However, other recent sampling data (not analyzed here) reports winter diazinon *C. dubia* LC_{50} exceedances at a number of other Sacramento Valley locations (Sacramento River Watershed Program 1999 – 2000 winter event-based monitoring, http://www.sacriver.org/).

Table 7. Diazinon exceedance frequencies (percent) for data in DPR's 1997 - 2001 dormant spray monitoring studies (Dec - Mar sampling only, studies 32, 33, 37, 38, 57, 58, 62, 63, 70, 71, appendix 1).

DIAZINON - DPR Sacramento River Studies	**Criterion ug L^{-1}**	**Exceedance Frequency (%)**		
Criterion - source		**Sacramento River**	**Wadsworth Canal**	**Sutter Bypass**
chronic aquatic tox - CDFG 2000	0.05	12	65	24
acute aquatic tox - CDFG 2000	0.08	3	55	9
Ceriodaphnia dubia LC_{50} - CDFG 1998	0.436	0	17	0
Drinking water Lifetime Health Action Advisory Level - U.S. EPA	0.600	0	11	0

DIAZINON - DPR San Joaquin River Studies	**Criterion ug L^{-1}**	**Exceedance Frequency (%)**	
Criterion - source		**San Joaquin River, Vernalis**	**Orestimba Creek, River Road**
chronic aquatic tox - CDFG 2000	0.05	12	8
acute aquatic tox CDFG 2000	0.08	5	4
Ceriodaphnia dubia LC_{50} - CDFG 1998	0.436	0	0
Drinking water Lifetime Health Action Advisory Level - U.S. EPA	0.600	0	0

VI. CO-OCCURRENCE AND TOXICITY

Organophosphate pesticides (OP) display a common mechanism of acute toxicological action, so that additive toxicity of diazinon and chlorpyrifos is expected and has been observed in aquatic organisms (Bailey et al., 1997; Giesy et al., 1999). Diazinon and chlorpyrifos are the two most commonly detected OPs in the SWD. Detections of other OP insecticides have been reported in the SWD but their detection frequencies are much lower than diazinon and chlorpyrifos (e.g., methidathion, 6.7 percent). Consequently, while other OPs were not considered in this co-occurrence analysis for simplicity, it should be recognized that they are also occasionally be present in aquatic systems.

Across the entire data set, 3,716 sample events included analysis of both diazinon and chlorpyrifos. In these data the conditional frequency that a sample was positive for chlorpyrifos given that it was positive for diazinon is 54 percent, i.e., more than half of all diazinon detections were also positive for chloropyrifos (Figure 18). Co-occurrence was especially frequent in those samples that were positive for chlorpyrifos; more than 90 percent of such samples were also positive for diazinon (Figure 18).

Similar to single pesticide detection frequencies, co-occurrence frequencies are strongly affected by the LOQ of both analytes - in this case diazinon and chlorpyrifos. More than 70 percent of samples in which both diazinon and chlorpyrifos were detected were from Orestimba Creek (Appendix 6). Daily sampling occurred at each of 3 sites on Orestimba Creek during 1996 - 1997; the samples were analyzed for both diazinon and chlorpyrifos with very low LOQs (= 0.001 ug/L). One reason for the high number of co-occurrence detections at Orestimba is the low LOQs employed in the chemical analysis; the number of Orestimba co-occurrence detections based on censored data is 67 as compared to 707 based on the uncensored data.

Toxic Units, TU

Chlorpyrifos is more acutely toxic to many aquatic species than diazinon (Table 8), consequently the toxicity of diazinon/chlorpyrifos mixtures cannot be estimated by directly summing their concentrations.

Table 8. Chlorpyrifos and diazinon LC_{50}s (ppb) for various aquatic species.

Common Name	Taxonomic Name	Chlorpyrifos	Diazinon
Sheepshead minnow	*Cyprinodon variegatus*	194	470
Water flea	*Daphnia magna*	0.9	1
Bluegill sunfish	*Lepomis macrochirus*	7.4	221
Striped mullet	*Mugil cephalus*	5.4	150
Mysid	*Mysidopsis bahia*	0.04	4.2
Cutthroat trout	*Oncorhynchus clarki*	5.4	1700
Rainbow trout	*Oncorhynchus mykiss*	12	460
Grass shrimp	*Palaemonetes pugio*	1.5	28
Brown shrimp	*Penaeus aztecus*	0.2	28
Fathead minnow	*Pimephales promelas*	151	7800
Lake trout	*Salvelinus namaycush*	73	600

source: U.S. EPA Office of Pesticide Programs, Env. Fate and Effects Division
Ecotox database, July 2000
data from multiple determinations given as geometric mean

The common approach to estimating joint acute OP aquatic toxicity is to use toxic units (TU, e.g. Miller and Miller, 2000). The TU for a single OP is calculated from a sample's measured analytical OP concentration and the known LC_{50} for that OP.

[1] TU = [OP concentration]/(LC_{50})

Toxic units may be considered as the number of LC_{50} concentration units, or toxic equivalents, in a sample. For instance, if a sample's chlorpyrifos concentration (chlorpyrifos LC_{50} = 0.038 ug L^{-1}) is 0.038 ug L^{-1}, the sample "contains" 1 TU of chlorpyrifos. Similarly, chlorpyrifos concentrations of (***2*** x 0.038) = 0.076, (***3*** x 0.038) = 0.114 and (***0.5*** x 0.038) = 0.019 ug L^{-1} correspond to 2, 3, and 0.5 TUs, respectively.

For chemicals with a common mode of action - such as the cholinesterase-inhibiting OPs - TUs are additive so that the toxicity of a sample is estimable by adding the TU contribution from each OP. For example, if diazinon and chlorpyrifos are both present n a sample the acute toxicity of the sample to *C. dubia* expressed in TU (LC_{50} equivalents) is given by equation 2.

[2]	TU_{total}	$= TU_{chlorpyrifos}$	$+ TU_{diazinon}$
		= (chlorpyrifos conc.) /chlorpyrifos LC_{50}	+(diazinon conc.)/diazinon LC_{50}
		= [*chlorpyrifos ug/L*]/0.038 ug/L	+[*diazinon ug/L*]/0.436 ug/L

Theoretically, toxic units are an approximate indicator of toxicity because the “true” toxicity of a sample may depend not only on the analytical OP chemical concentration, but on other factors including the sample matrix. For example, sorption of chlorpyrifos to suspended sediment or dissolved humic materials could mitigate aquatic toxicity by reducing bioavailability. Conversely, the presence of other stressors or synergists may enhance OP toxicity. The joint chemistry/toxicity data in this data set provide an opportunity to compare *observed* sample toxicities to those *predicted* based on concentration and laboratory measured LC_{50}s.

Comparison of toxicity and analytical chemical results

There were 488 samples collected between 1991 and 2000 for which both analytical chemical and *C. dubia* acute toxicity testing data were available. The toxicity data analyzed here included only those toxicity test results in which the control survival percentage was 90 percent or greater (U.S. EPA, 1993). Figure 19 illustrates the combined chemistry and C. *dubia* mortality data.

In the SWD, "significant acute toxicity" is defined as a difference of 30 or more in percent survival between the control and sample. Of the 488 acute toxicity tests, 143 (29 percent) showed significant toxicity to *C. dubia*. Among these, tributary samples showed a higher incidence of significant toxicity than river samples: 129 of 301 tributary toxicity tests were significant (43 percent), whereas 14 of 187 river samples demonstrated significant toxicity (7 percent). All of the river samples were collected during the 1991 - 1995; the most recent river sample acute toxicity tests were in 1995.

While samples classified as “significantly toxic” and “not significantly toxic” according to the SWD criteria displayed significantly different median TUs (Figure 20), the more important result is illustrated in Figure 21: significant toxicity was consistently observed in those samples with calculated TU greater than 0.5. However, in approximately half of the 30 samples that meet the condition 0.5 < TU < 1.0, other constituents were present in amounts sufficient to either cause or significantly contribute to toxicity. These included ammonia, malathion, ethyl parathion, and fonofos (ethyl parathion and fonofos are no longer registered for use in California). Consequently the threshold of TU = 0.5 is probably a conservative indicator of diazinon and/or chlorpyrifos toxicity since many times other constituents apparently contributed to toxicity of samples in the 0.5 < TU <1.0 range.

While predicted and observed toxicities agreed generally in the 488 samples, there were some cases of inconsistencies between observed and TU-predicted *C. dubia* toxicity. Figure 22A illustrates 12 samples (grey data points) that actually displayed 100 percent toxicity but were predicted to display no toxicity <u>based solely on chlorpyrifos and diazinon concentrations</u> (i.e., TU < 0.1). The original study data (study 43) indicates that in 9 of those 12 samples at least part - if not all - of the observed toxicities are attributable to other constituents that were measured; these include ethyl parathion, fonofos, and ammonia. There were 7 data points (blue) in which TU-predicted toxicity (TU > 0.5) was not observed (Figure 22B); 4 of these data had calculated TU greater than 1.0. The specific reasons are unclear, but may include (i) reduced organophosphate bioavailability resulting from sorption to consitutents in the sample matrix (sediment and/or humic materials), (ii) antagonistic interactions by other sample constituents, or (iii) experimental error.

VII. DETECTION FREQUENCY/CONCENTRATION TRENDS

Diazinon

There were two sampling sites that met the following conditions: (i) sampling was conducted both “early” (i.e. ≥ 6 years ago) in the last decade and recently (within the last 5 years), and (ii) the early and recent samplings at the site were both performed during the same time of year. The two sites that met these criteria were the San Joaquin River near Vernalis (site

3917) and Orestimba Creek at River Road (site 5028, Figure 23). Changes in diazinon detection frequency and concentrations were evaluated in these two data subsets.

Comparisons at Vernalis were made between 2 time periods: 1991-1995 and 1997-2001. Comparisons at River Road, Orestimba Creek were between the time periods 1991-1993 and 1997 - 2001. All data were (a) concentration censored (all data with reported concentrations < 0.04 defined as nondetection) and (b) "seasonal censored", where data for April through November, inclusive, were removed. The rationale for concentration censoring has been previously discussed; the procedure provides a similar basis to compare detection frequencies between different studies. As discussed previously, censoring of data obtained with an LOQ greater than the censoring threshold causes a downward bias in censored detection frequency. This effect is negligible for these two datasets because only nine and seven samples were analyzed with an LOQ greater than the censoring threshold of 0.04 ug/L at Vernalis and the Orestimba Creek River Road site, respectively. Because all of the later data (years 1997 – 2001) at both sites were from DPR's Dec – Mar dormant spray studies, removal of the early decade April - November data was necessary to eliminate potential bias due to seasonal differences in detections and/or concentrations.

The concentration and seasonal censored wintertime Vernalis data were relatively evenly distributed between the "early" (1991 – 1995) and "recent" (1997 – 2001) time period groups, and between years within groups (Figure 24). However, the between and within group distribution of the Orestimba Creek River Road censored data was skewed (Figure 24). There were a limited number of early, or 1991 – 1993 samples, and within the early group there were an inordinate number of samples from 1993 relative to 1991 and 1992. Similarly, the recent 1997 – 2001 Orestimba data were heavily weighted toward dormant sampling year 1997. Consequently there is limited confidence surrounding conclusions based on the Orestimba Creek data due to potential bias; the data are presented here primarily as qualitative information.

Forty-eight percent of the censored 1991-1995 Vernalis diazinon data were detections, whereas sixteen percent of the more recent 1997 – 2001 data were detections. The difference between detection frequencies in the two time periods is greater than would be expected based on chance alone ($p<0.0001$, Figure 25). The mean rank of diazinon concentration for the period 1991-1995 is greater than the mean rank for the 1996-2000 period based on a nonparametric analysis of variance ($p<0.0001$, Figure 26), i.e., diazinon concentrations were significantly lower in the recent time period (Figure 27).

The foregoing analysis of the Vernalis data assumes that the samples were random samples during the respective time periods. Therefore, the conclusion of higher detection frequencies and concentrations in the early 1990s should be accepted cautiously; the actual confidence level may not be as high as indicated. One reason is the potential bias due to differences in sampling during the 2 time periods; nearly all of the 1991-1995 Vernalis data were obtained from study 9 (USGS, appendix 1), where the authors state "samples collected during 2 or more consecutive days usually were combined for analysis. During critical sampling periods such as during periods of rainfall, water samples collected during a single day were analyzed." Because the wintertime detections and peak concentrations are typically associated with rainfall events, such a targeted sampling and analysis scheme may potentially bias detection frequencies (and possibly concentrations of the upper centiles) upwards relative to the fixed schedule sampling regime utilized during the 1997-2001 studies.

Although a similar analysis of the Orestimba Creek data (not shown) also indicates that 1991-1993 detection frequencies and median concentrations were higher than in 1997-2001, there was an extreme bias in the distribution of sampling over time as noted previously. The cumulative frequency concentration distributions for the two time periods at Orestimba Creek are shown in Figure 28, suggesting that recent diazinon concentrations might be lower than those in the past.

Relationship of Vernalis sampling data and diazinon use Diazinon wintertime detections above the censoring threshold of 0.04 ug L^{-1} were more frequent and concentrations were higher during the early 1990's at Vernalis than in recent years. Mean January/February rainfall was similar during the early 1990s and the later period; in Modesto the mean 1991-1995 rainfall during January and February was 5.4 inches while that during 1997-2001 was

6.4 inches. This suggests a different causative factor, such as the sharp reduction in diazinon wintertime use in recent years (Figure 9). The significant correlation between winter detection frequency at Vernalis and amount of diazinon applied in winter suggests that reduced use plays an important role in lower recent detection frequencies in the San Joaquin River (Figure 29).

Chlorpyrifos

Of 434 samples taken at Vernalis between 1991 – 2001 and analyzed for chlorpyrifos, only one sample exceeded the censoring threshold of 0.04 ug/L. Consequently no comparisons were made using the Vernalis data. The Orestimba Creek chlorpyrifos data are subject to the same caveats as the diazinon data discussed above – distribution of sample events across years was heavily biased toward the years 1993 and 1997. In addition, while there were 20 chlorpyrifos detections above the censoring threshold of 0.04 ug/L in the 1997 - 2001 time period, 19 of these detections occurred during a three week span in March, 1997. Consequently the data are not representative of the 1997 - 2001 time period; no comparisons of chlorpyrifos were performed.

VIII. SUMMARY

Data

Seven thousand eight hundred sixty two concentration measurements of chlorpyrifos and diazinon obtained between 1991 - 2001 were analyzed in conjunction with 1991 - 2000 pesticide use data. Also evaluated were 488 *C. dubia* acute toxicity tests conducted over the last decade. The data were compiled from 22 studies with varying study designs and objectives. Consequently the data represent a “patchwork” of information. The geographical and temporal distribution of data is uneven, and the data were obtained using widely varying limits of quantitation (LOQ).

Some important features of the data are:

- Nearly all of the diazinon and chlorpyrifos data were paired measurements, obtained from a common sampling event and usually analyzed using a similar or equal LOQ.

- Chemical analytical data from two sites with frequent long-term sampling (chlorpyrifos at Orestimba Creek, State Hwy. 33, and diazinon at the San Joaquin River, Vernalis) demonstrated significant auto-correlation, indicating that concentrations were not random over time, but tended to be episodic over characteristic time scales on the order of days. This is probably a general characteristic of data from most sites, and means that exceedances on adjacent or proximate days are not, in general, independent events.

- Chemical analytical data from adjacent sites were significantly correlated. This is probably a general characteristic of most proximate sites, and means that detections at adjacent sites are not, in general, independent events.

- Detection frequency is strongly dependence on LOQ. Consequently detection frequency data from different sources must be censored to a common detection threshold prior to comparison to avoid bias. Detection frequencies are only appropriate for relative comparisons, and serve poorly as objective measures of water quality.

Pesticide Use

Diazinon

- Diazinon use in the Sacramento and San Joaquin basins has decreased steadily since 1993. The reported 2000 use of 275,000 pounds was less than 40 percent of use in 1993.

- Recent use data show that the largest amounts of diazinon are applied during the rainy season of January - February. The data does not include homeowner applications.

- These winter rainy season applications of diazinon are principally to fruit and nut orchards, including almonds, peaches, nectarines, plums, apples, cherries, apricots, and prunes.

Chlorpyrifos

- Reported use of chlorpyrifos in the Central Valley doubled from 1991 to 1997, but use has steadily declined since 1997. In 2000 reported chlorpyrifos use in the Sacramento and San Joaquin River basins was 511,000 pounds, approximately 40 percent of use in 1997.

- Little chlorpyrifos is applied during the winter rainy season. The peak application season for chlorpyrifos is June - August. The largest amounts are applied to nuts (mostly almonds), with substantial amounts also applied to cotton in the San Joaquin Valley.

Monitoring Data (1991 - 2001)

Diazinon

- Diazinon concentrations and detection frequencies were generally higher in tributaries than rivers.

- There were 414 detections of diazinon in 2130 river samples. All of the 100 highest diazinon river concentrations were reported in the early 1990's. However, the number of river sites sampled and total number of samples were low in recent years.

- There were 562 diazinon detections in 1824 tributary samples. The 100 highest diazinon tributary detections were greater than or equal to 0.5 ug/L and occurred at various times and locations the last decade.

- Eleven of the top 100 diazinon tributary detections were reported during the last five years. These 11 samples were all from Wadsworth Canal in Sutter County. Wadsworth is one of only four tributary sites sampled since 1997 in the data set analyzed here. However, other recent sampling data (not analyzed here) reports recent winter *C. dubia* LC_{50} diazinon exceedances at a number of other Sacramento Valley locations.

These data were reported in a 1999-2000 draft Sacramento River Watershed Program winter event-based monitoring report (http://www.sacriver.org/).

- Exceedances of DFG's acute aquatic diazinon criterion were 11 and 22 percent for river and tributary sites, respectively. Exceedance percentages of the *C. dubia* LC_{50} were one and six percent for river and tributary sites, respectively. There has not been a reported exceedance of the *C. dubia* diazinon LC_{50} at a river site since January 1994.

- There was sufficient data at one site to quantitatively compare "early" (1991 - 1995) and "recent" (1997 - 2001) sampling results: the San Joaquin River near Vernalis. Diazinon concentrations in Dec - Mar were significantly lower at Vernalis during 1997 - 2001 than in 1991 - 1995.

- Using a concentration censoring threshold of 0.04 ug/L, the winter diazinon detection frequency at Vernalis during 1997 - 2001 was 16 percent as compared to 48 percent in the earlier 1991-1995 time period.

- A nonparametric analysis of variance on ranks of the concentration data indicates that diazinon concentrations at Vernalis were significantly lower during 1997 – 2001 than during the earlier 1991 – 1995 time period.

- Diazinon detection frequency at Vernalis was significantly correlated with diazinon use in the San Joaquin basin, indicating that the reduction in diazinon use has led to lower detection frequencies at Vernalis.

Chlorpyrifos

- Chlorpyrifos concentrations and detection frequencies were generally higher in tributaries than rivers.

- There were 120 detections of chlorpyrifos in 2082 river samples. All chlorpyrifos river detections occurred during 1991 - 1995; there has not been a chlorpyrifos river detection since that time. However, the number of both river sites sampled and total samples were much lower in recent years than during the early period 1991 - 1995, and the LOQ in recent studies (0.04 ug/L) is higher than employed in many past studies. In addition, recent monitoring has focused on the winter dormant season as opposed to summer when mass of applied chlorpyrifos is greatest.

- There were 990 chlorpyrifos detections in 1795 tributary samples. Seventy nine percent of these detections were from an intensive one-year monitoring study of 3 proximate sites on Orestimba Creek in 1996 - 1997 that utilized a very low LOQ (0.001 ug/L). In more recent 1997 - 2001 winter monitoring chlorpyrifos was detected in one of 95 samples from the Orestimba Creek River Road site based on LOQ = 0.04 ug/L.

- Across all sampling data, exceedances of DFG's acute aquatic chlorpyrifos criterion were 3 and 26 percent for river and tributary sites, respectively. These are low-biased estimates of exceedance because some monitoring programs utilized LOQ that were greater than the acute criterion. Exceedance percentages of the *C. dubia* chlorpyrifos LC_{50} were 2 and 15 percent for river and tributary sites, respectively. There has not been a reported exceedance of the *C. dubia* chlorpyrifos LC_{50} at a river site since January 1995. Of the 30 river samples that exceeded the *C. dubia* LC_{50} during 1991 - 1995, one-half were Alamo River samples collected in fall 1993.

- Nearly all of the 100 highest chlorpyrifos concentrations in tributaries (> 0.15 ug/L) were from 3 sites on Orestimba Creek. These samples were collected during daily sampling in 1996 - 1997. In subsequent 1997 - 2001 winter sampling (Dec - Mar only) at the Orestimba Creek, River Road site there was one chlorpyrifos detection in 95 samples at an LOQ of 0.04 ug/L

Co-occurrence and toxicity

- Conditional co-occurrence frequencies of chlorpyrifos and diazinon describe the frequency with which one pesticide is detected given that the other is present. Co-occurrence of chlorpyrifos and diazinon across the entire data set was more frequent than expected based on chance alone. The frequency that chlorpyrifos was detected given that diazinon was detected was 55 percent; the frequency that diazinon was detected given that chorpyrifos was present was more than 90 percent. However, these frequencies are strongly dependent on LOQ. Consequently the co-occurrence data are not quantitative. Nearly 75 percent of co-occurrence detections were observed at three Orestimba Creek sites.

- In 488 acute *C. dubia* toxicity tests, significant toxicity was observed in 143 tests (29 percent). Among these, there was a higher incidence of significant toxicity among tributary samples than in river samples: 129 of 301 tributary toxicity tests were significant (43 percent), whereas 14 of 187 river samples demonstrated significant toxicity (7 percent). There were no reported acute toxicity test data for any river sites after 1995.

- Across all data, analytical concentrations and acute toxicity testing data were significantly correlated; more than 90 percent of samples with TU > 0.5 (calculated from analytical diazinon and chlorpyrifos concentrations) displayed significant toxicity. However, other toxicants such as ammonia, ethyl parathion, and fonofos contributed to or caused observed toxicity in many cases. Consequently the condition TU > 0.5 is conservative for predicting diazinon and/or chlorpyrifos toxicity to *C. dubia*. Among those samples that were not predicted to be toxic based on diazinon and/or chlorpyrifos (TU < 0.1), 2.5 percent or 12 samples displayed significant toxicity. The observed toxicity appeared to be at least partially attributable to other measured chemical constituents in nine of these samples.

- In 4 years of recent winter dormant season monitoring (1997 - 2000), significant acute toxicity has been observed in a Sacramento River tributary and a San Joaquin River tributary.

  (i) Wadsworth Canal (site 5113). Eighteen of forty one *C. dubia* acute toxicity assays (44%) showed significant acute toxicity. Diazinon was detected in all toxic samples, and 15 of the 18 toxic samples were predicted to be toxic based on TU ≥ 0.5. There was no toxicity observed in any Wadsworth samples with TU < 0.4. Diazinon was associated with observed toxicity at this site.

  (ii) Orestimba Creek , River Road (site 5028). Eight of seventy-two *C. dubia* acute toxicity assays (11%) showed significant acute toxicity. Diazinon was detected in two of the eight toxic samples at concentrations corresponding to less than 0.15 TU; chlorpyrifos was not detected in any of the eight samples at an LOQ of 0.04 ug/L. Based on the analytical concentrations. diazinon was not the principal source of toxicity in these samples. Chlorpyrifos may have contributed, but this is indeterminant from the data because the chlorpyrifos LOQ was greater than the *C. dubia* chlorpyrifos LC_{50}.

IX. CONCLUSIONS

1. Use of both diazinon and chlorpyrifos has steadily decreased in recent years. In 2000, reported applications of diazinon in the Sacramento and San Joaquin river basins were 38 percent of those in 1993. In 2000, reported applications of chlorpyrifos in the Sacramento and San Joaquin river basins were 42 percent of that in 1997.

2. The highest river concentrations of diazinon and chlorpyrifos were reported during the early 1990s. However, recent river sampling for both has been limited. There have been no river detections of chlorpyrifos since March 1995.

3. In general, both pesticide detections and significant acute toxicity have been more frequent in tributaries than in rivers.

4. Winter (Dec - Mar) diazinon concentrations and detection frequencies at Vernalis, San Joaquin River, were significantly lower in 1997 - 2001 than in 1991 - 1995.

5. Winter diazinon detection frequencies at Vernalis are significantly correlated with diazinon use. Lower diazinon detection frequencies at Vernalis in recent years are at least partially attributable to decreased winter diazinon use in the San Joaquin River basin.

6. Regular winter dormant season exceedances of the diazinon *C. dubia* LC_{50} have been recently observed in Sacramento River tributaries. Recent diazinon concentrations at Wadsworth Canal have ranged up to approximately 6 times the *C. dubia* LC_{50}.

7. In recent winter dormant season monitoring (1997 - 2000) significant *C. dubia* acute toxicity has been observed in bioassay samples from both sites sampled: a Sacramento River tributary (Wadsworth Canal, 18 of 41 samples) and a San Joaquin River tributary (Orestimba Creek at River Road, 8 of 72 samples). Diazinon was associated with toxicity at Wadsworth Canal, but not at Orestimba Creek. The potential contribution of chlorpyrifos to the Orestimba toxicity is indeterminate due to the high LOQ relative to the *C. dubia* chlorpyrifos LC_{50}.

8. There have been no reported exceedances of the *C. dubia* diazinon LC_{50} in the San Joaquin River at Vernalis or the Sacramento River above Sacramento during the last five years of winter monitoring. The DFG diazinon acute toxicity criterion was exceeded five and three percent of the time at Vernalis and the Sacramento River, respectively, during 1997 - 2001 winter monitoring.

9. During 1997 - 2001 winter monitoring, there was one detection of chlorpyrifos in 263 tributary samples. However:
   (i) The peak use season for chlorpyrifos is during summer months; there is no recent monitoring data for chlorpyrifos in spring, summer, or fall months in DPR's SWD, and

(ii) all recent monitoring has been conducted with a relatively high LOQ of 0.04 ug/L. This LOQ was slightly higher than the *C. dubia* chlorpyrifos LC_{50} of 0.038 ug/L so that chlorpyrifos acute toxicity would be possible at concentrations less than the LOQ.

10. Acute toxicity to *C. dubia* was correlated with TU calculated solely from measured diazinon and chlorpyrifos concentrations; more than 90 percent of samples with TU > 0.5 were significantly toxic. However, the condition TU = 0.5 may be a conservative cut-off (i.e. low biased) for diazinon and/or chlorpyrifos toxicity to *C. dubia* because there were indications of other causes of toxicity: the data included several samples where toxicity was partially or wholly attributable to other measured contaminants.

X. REFERENCES

Bailey, H.C., J.L. Miller, M.J. Miller, L.C. Woborg, L. Deanovic, and T. Shed. 1997. Joint acute toxicity of diazinon and chlorpyrifos to *Ceriodaphnia dubia.* Environ. Tox. and Chem. 16:2304-2308.

Bennett, K., C.E. Nordmark, J. Schuette, H. Feng, J. Hernandez, and P. Lee. 1998. Occurrence of aquatic toxicity and dormant-spray pesticide detections in the San Joaquin River Watershed, Winter 1996-97. Dept. Pest. Reg., Environmental Hazards Assessment Program pub. EH 98-02.

C.E. Nordmark, K. Bennett, H. Feng, J. Hernandez, and P. Lee. 1998. Occurrence of aquatic toxicity and dormant-spray pesticide detections in the Sacramento River Watershed, Winter 1996-97. Dept. Pest. Reg., Environmental Hazards Assessment Program pub. EH 98-01.

California Department of Fish and Game. 2000. Water Quality Criteria for diazinon and chlorpyrifos. Administrative report 00-3.

California Department of Fish and Game. 1999. Test 68: 96-hour Acute Ceriodaphnia dubia test for chlorpyrifos. Aquatic Toxicology Laboratory, Elk Grove, California.

California Department of Fish and Game. 1998. Test 132: 96-hour Acute Ceriodaphnia dubia test for diazinon. Aquatic Toxicology Laboratory, Elk Grove, California.

Department of Pesticide Regulation, 2000. DPR's Surface Water Database. http://www.cdpr.ca.gov/docs/surfwatr/surfdata.htm, verified November 2, 2000.

Department of Pesticide Regulation, 2000b. DPR/U.C. Davis Interagency Agreement no. 00-0183S. Evaluation of potential matrix effects on ELISA determination of diazinon in Runoff water samples. Principal Investigators: S. Gee and B. Hammock .

Giesy, J.P., K.R. Solomon, J.R. Coates, K.R. Dixon, J.M. Giddings, and E.E. Kenega. 1999. Chlorpyrifos: Ecological risk assessment in North American aquatic environments.

Miller, J.L., and M.J. Miller. 2000. Identification of diazinon and chlorpyrifos toxicity to Ceriodaphnia in samples of water using antibody-mediated chemical-specific removal processes. Aqua-Science, produced under contract to the State Water Resource Control Board.

U.S. EPA. 1993. Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. Fourth Ed. EPA/600/4-90/027F.

U.S. EPA. 1998. Ambient aquatic life water quality criteria: diazinon. Office of Water draft document. September28, 1998.

U.S. EPA. 2000. Drinking water standards and health advisories. Office of Water, EPA pub. 822-B-00-001, August 2000.

FIGURES 1 – 29

Figure 1. Major surface water sampling sites 1991 - 2001

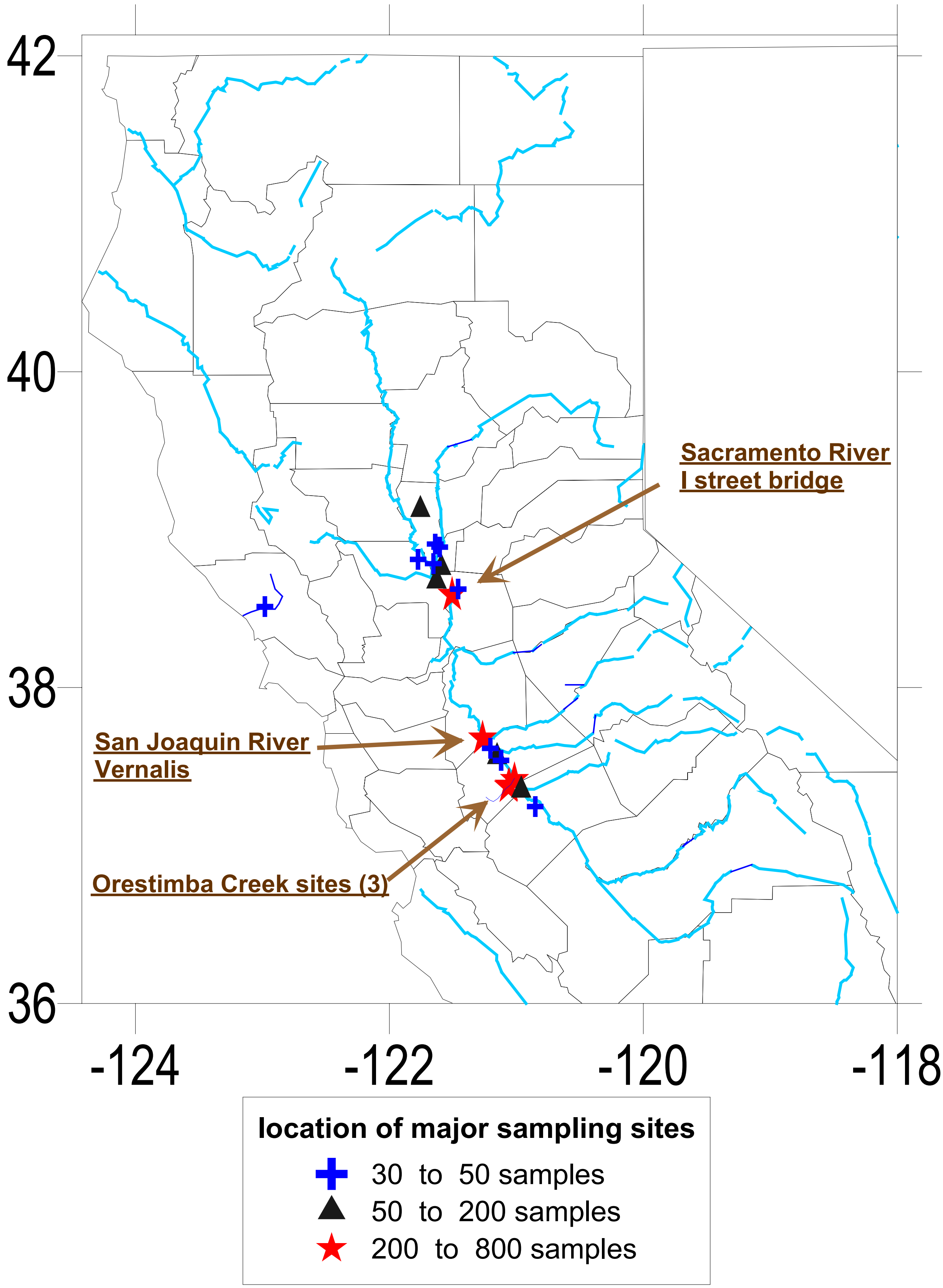


Figure 2. Diazinon and chlorpyrifos sampling by year.

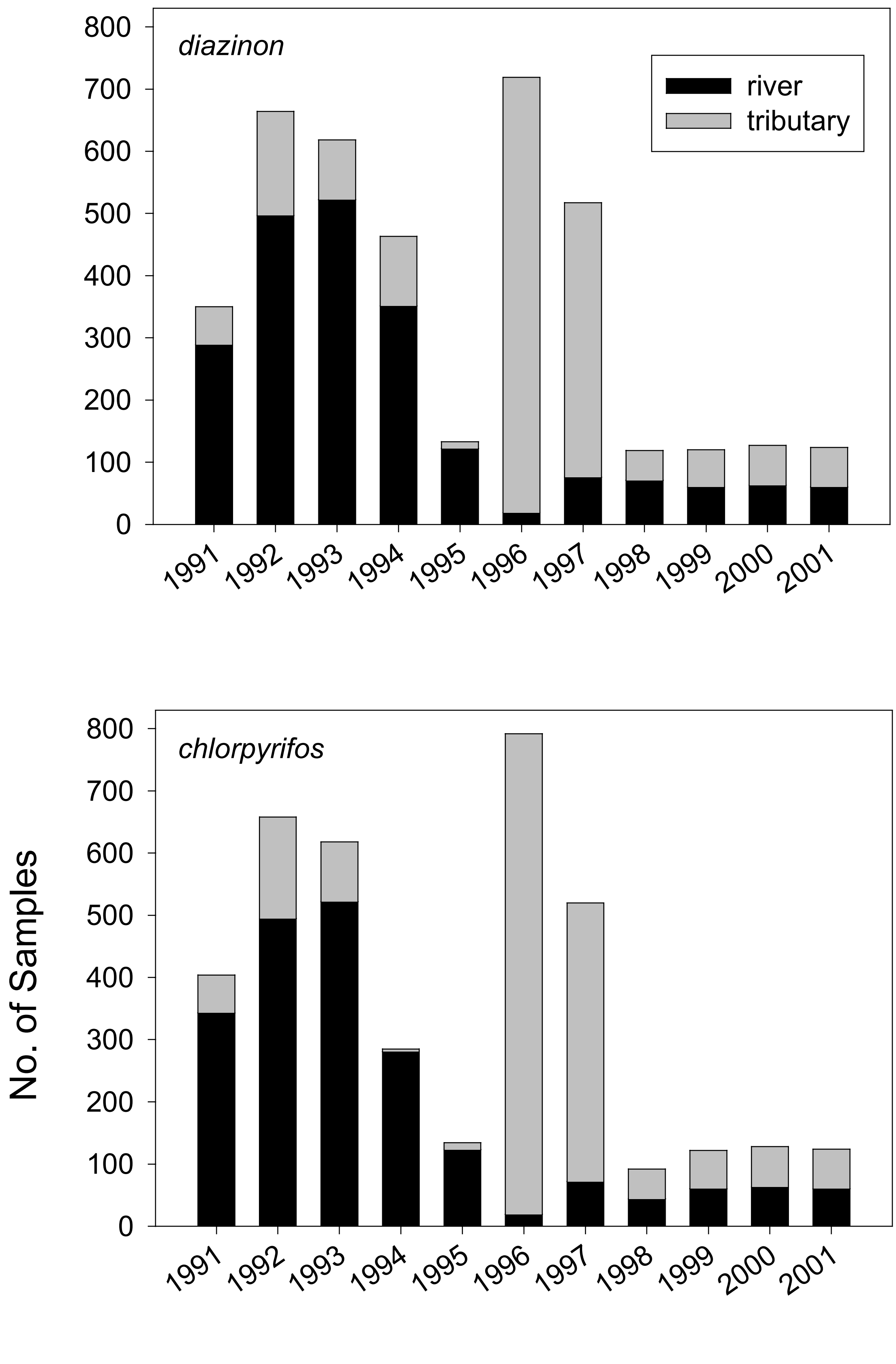


Figure 3. Diazinon and chlorpyrifos sampling by month

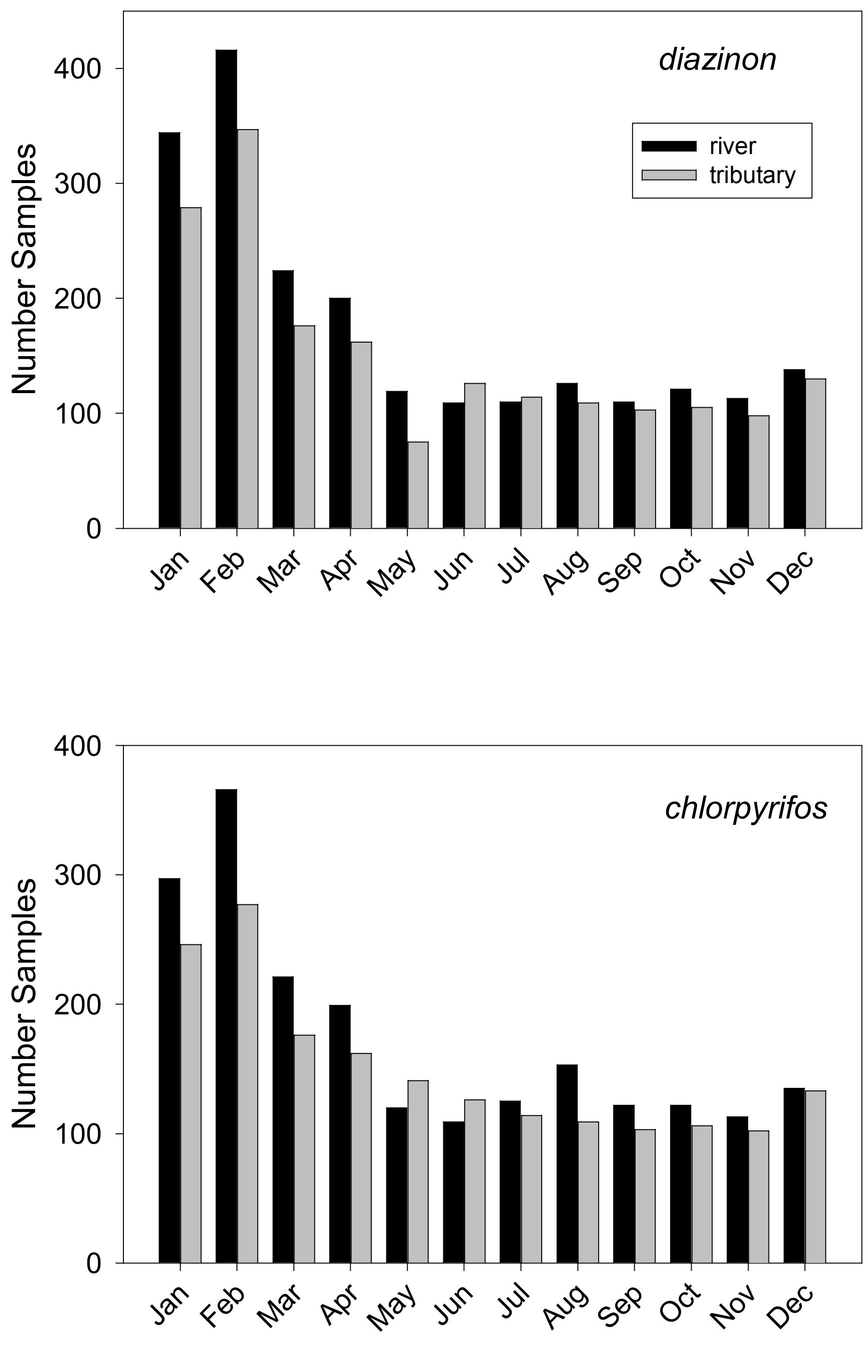


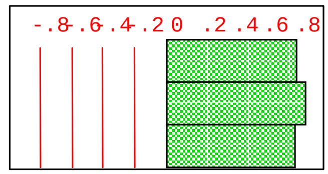
Figure 4. Correlation of daily chlorpyrifos data at 3 Orestimba Creek sites.

Correlations between sites

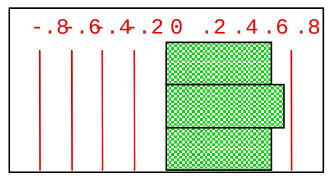
Sites	5026	5027	5028
5026	1.0000	0.5927	0.5930
5027	0.5927	1.0000	0.4116
5028	0.5930	0.4116	1.0000

Nonparametric Measures of Association

Site	by Site	Spearman Rho	Prob>|Rho|
5027	5026	0.8322	<.0001
5028	5026	0.8941	<.0001
5028	5027	0.8289	<.0001



Site	by Site	Kendall Tau b	Prob>|Tau b|
5027	5026	0.6749	0.0000
5028	5026	0.7561	0.0000
5028	5027	0.6708	0.0000



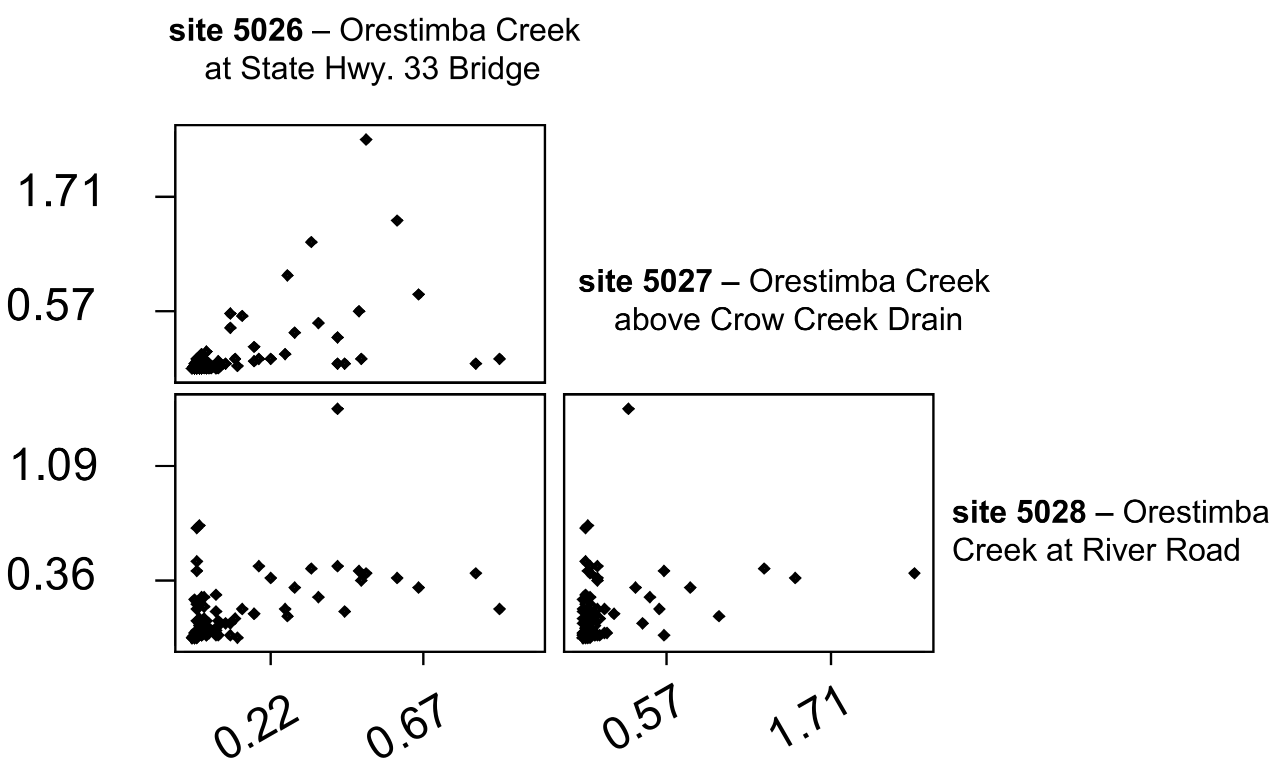
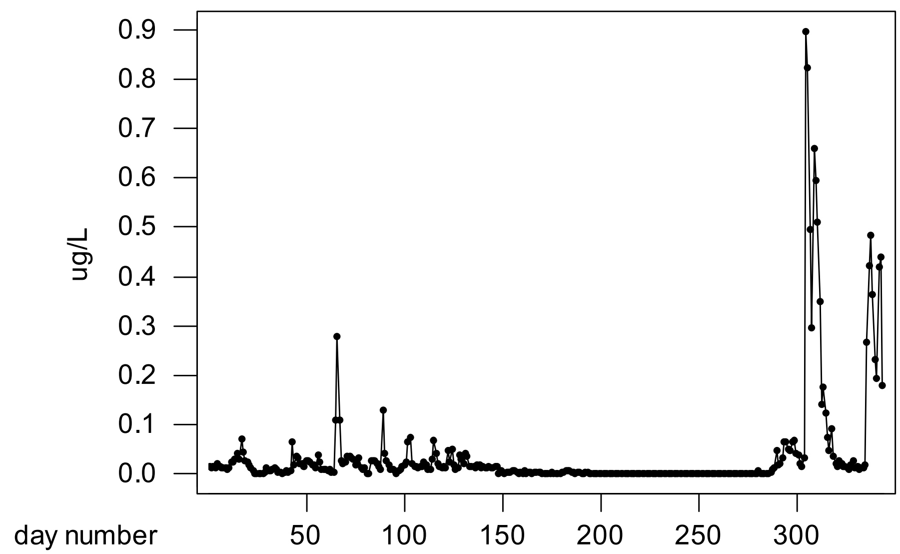


Figure 5. Chlorpyrifos time series plot, Orestimba Creek at State Hwy. 33
5/23/96 to 4/30/97, nondetections assigned value of zero



Autocorrelation function for chlorpyrifos data, Orestimba Creek at State Hwy. 33
5/23/96 to 4/30/97, nondetections assigned value of zero

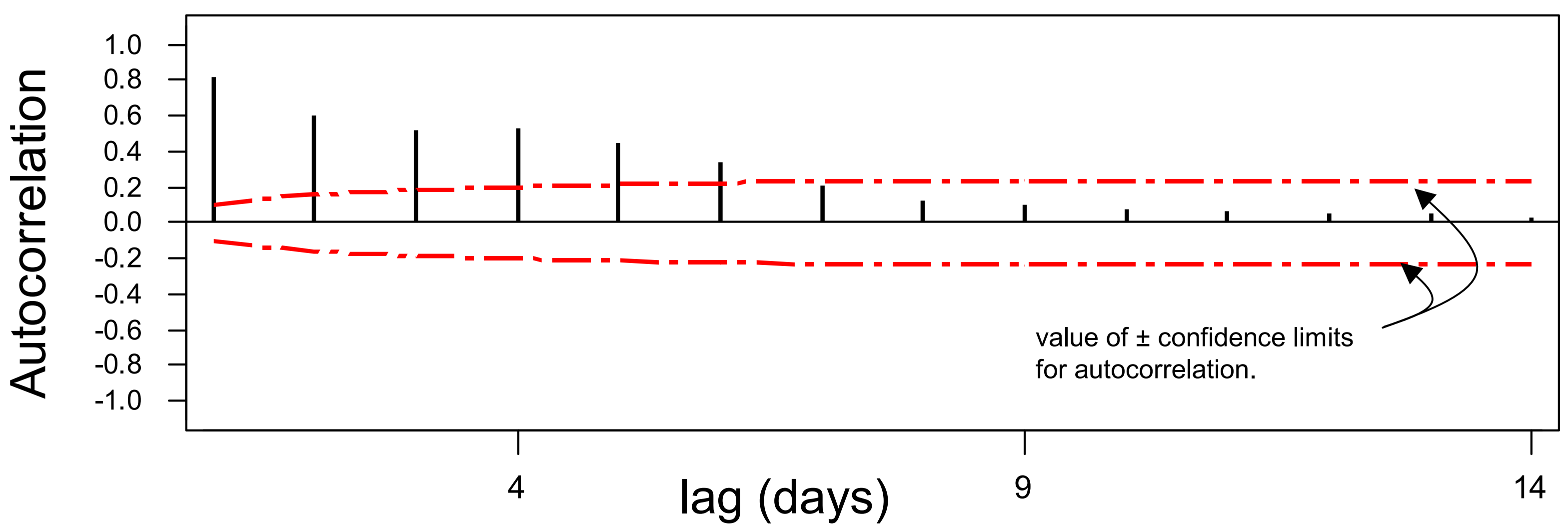
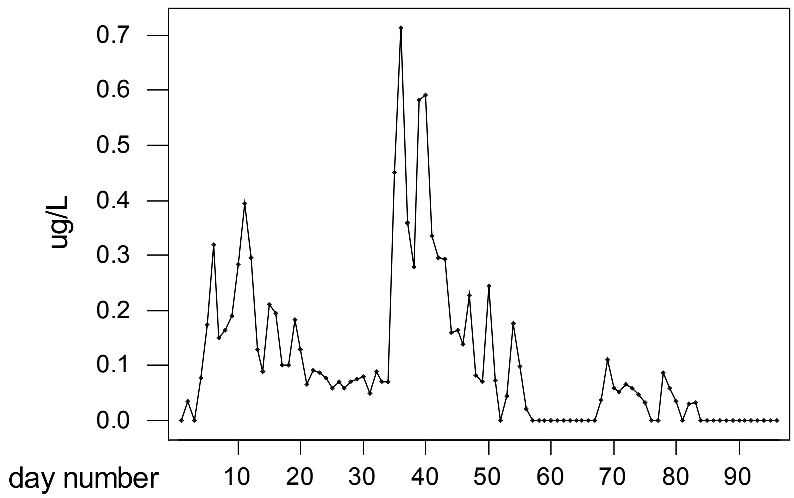


Figure 6. Diazinon time series plot, San Joaquin River at Vernalis
1/6/93 to 4/9/93, nondetections assigned value of zero



Autocorrelation function for diazinon data, San Joaquin River, Vernalis
1/6/93 to 4/9/93, nondetections assigned value of zero

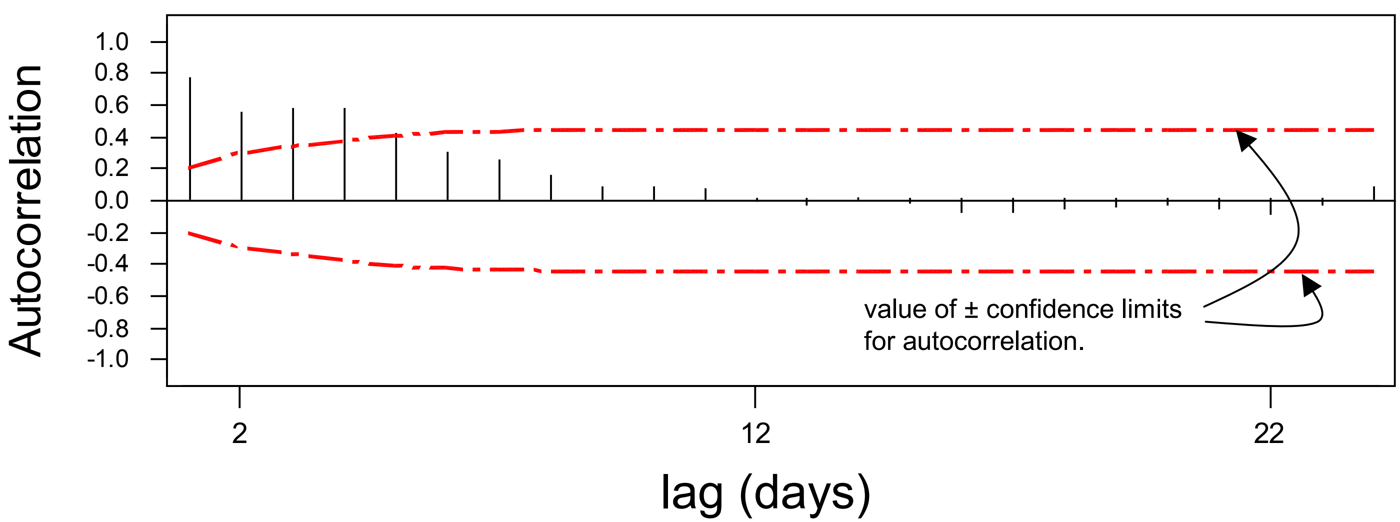


Figure 7. (a) Diazinon raw detection frequencies of river/tributary classifications by month. (b) "limit-of-quantitation" censored detection frequencies [same data as in (a)] demonstrating effect of LOQ on relative detection frequencies. Censoring rule: concentration < 0.04 ug/L = nondetection.

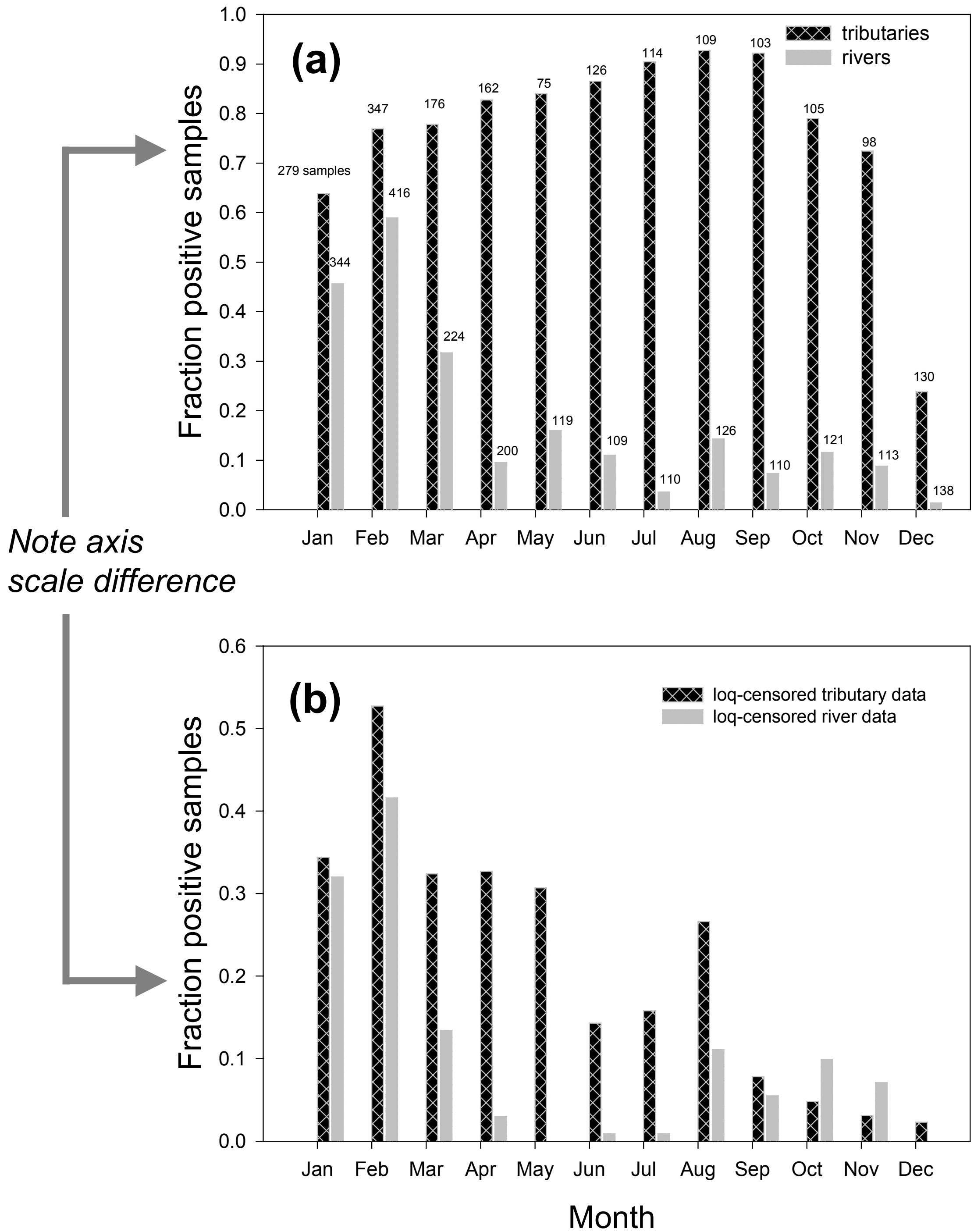


Figure 8. (a) Chlorpyrifos raw detection frequencies of river/tributary classifications by month. (b) “limit-of-quantitation” censored detection frequencies [same data as in (a)] demonstrating effect of LOQ on relative detection frequencies.
Censoring rule: concentration < 0.04 ug/L = nondetection.

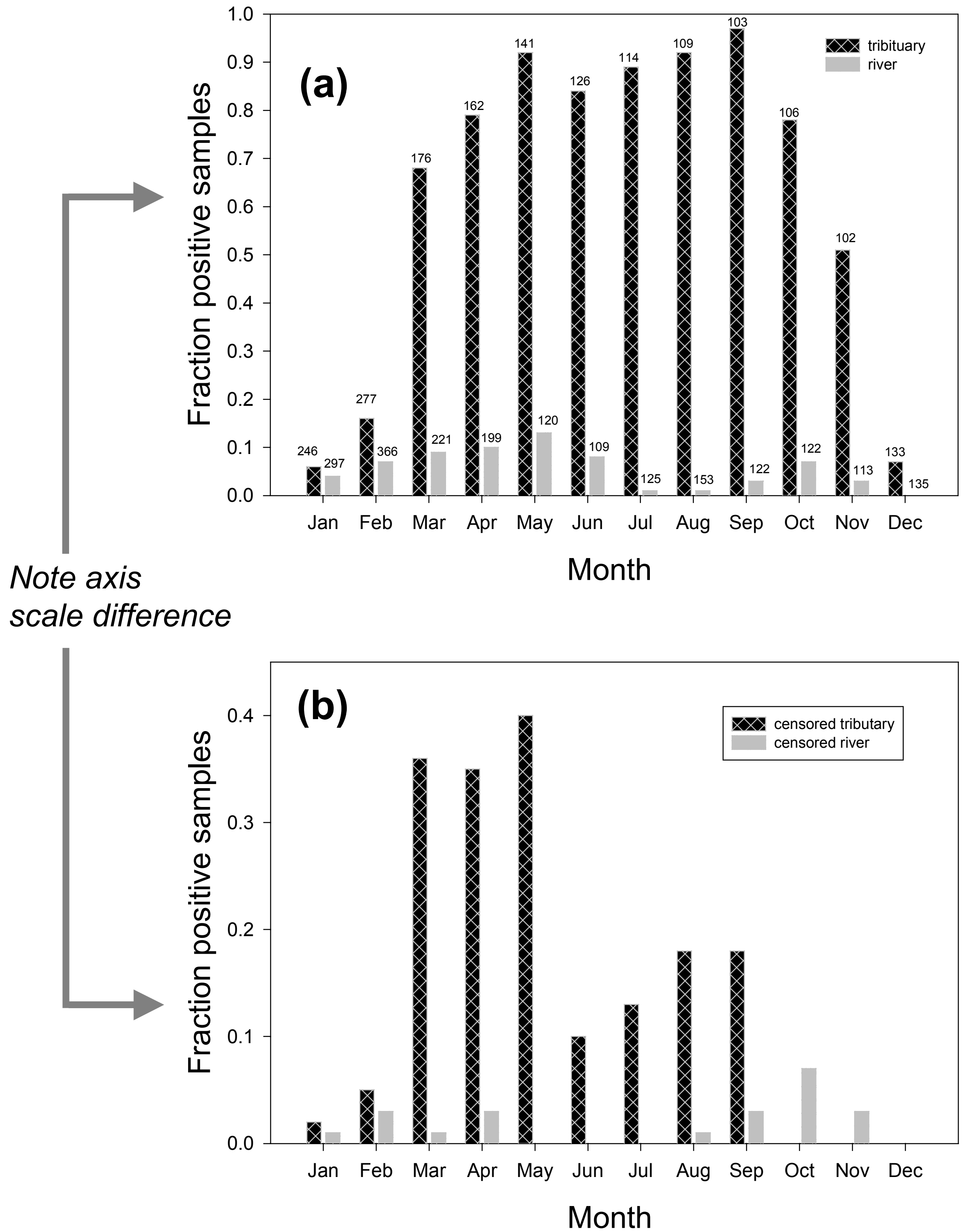


Figure 9. 1991 - 2000 organophosphate use in the Sacramento and San Joaquin River Basins

[Sacramento River basin includes Butte, Colusa, Glenn, Placer, Sacramento, Sutter, Tehama, Yolo, and Yuba Counties. San Joaquin basin includes Fresno, Madera, Merced, San Joaquin, and Stanislaus Counties]

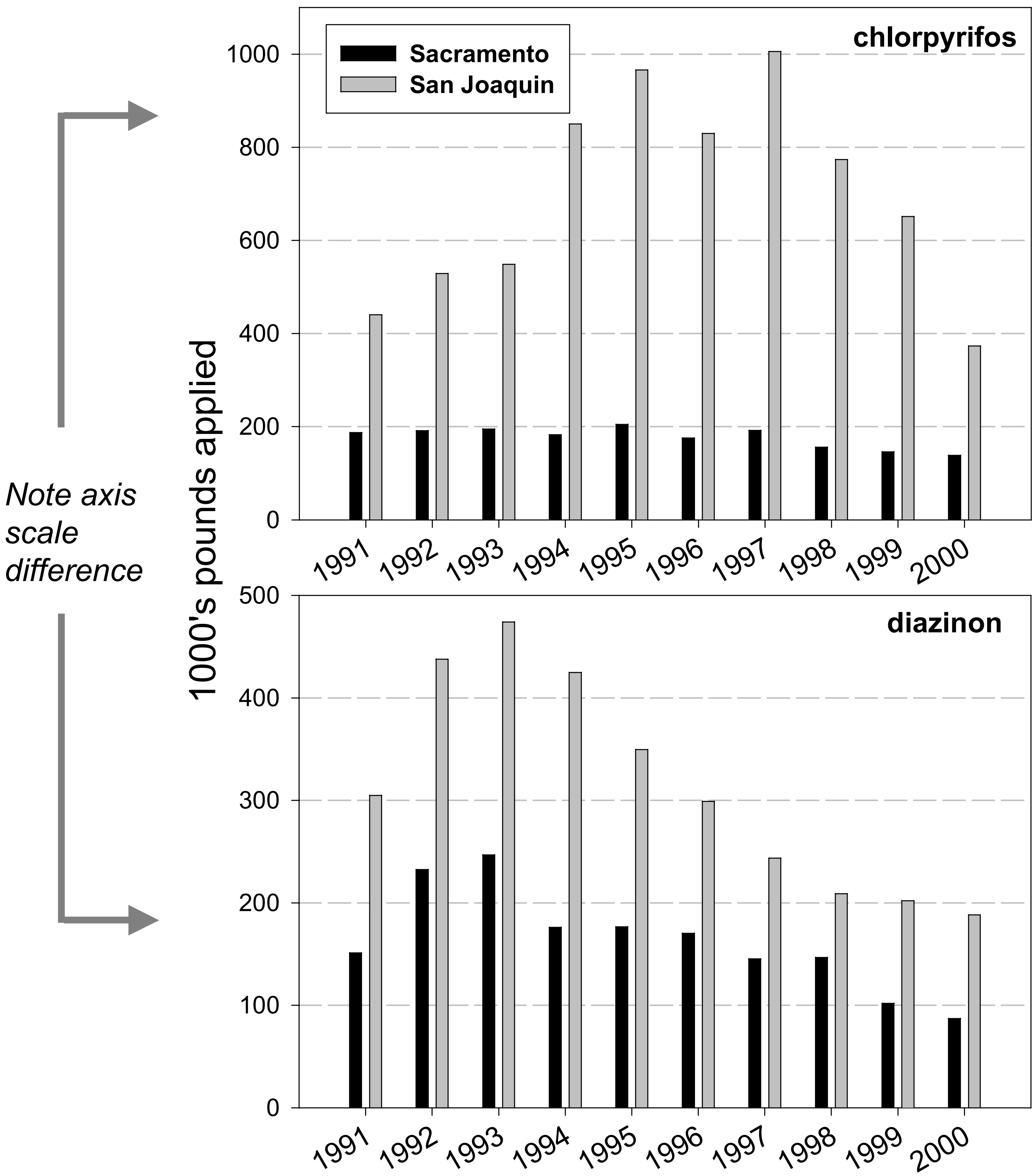


Figure 10. Annual wintertime (Dec-Mar) applications of chlorpyrifos and diazinon. Includes combined data from San Joaquin and Sacramento River basins. Crop types discussed in text.

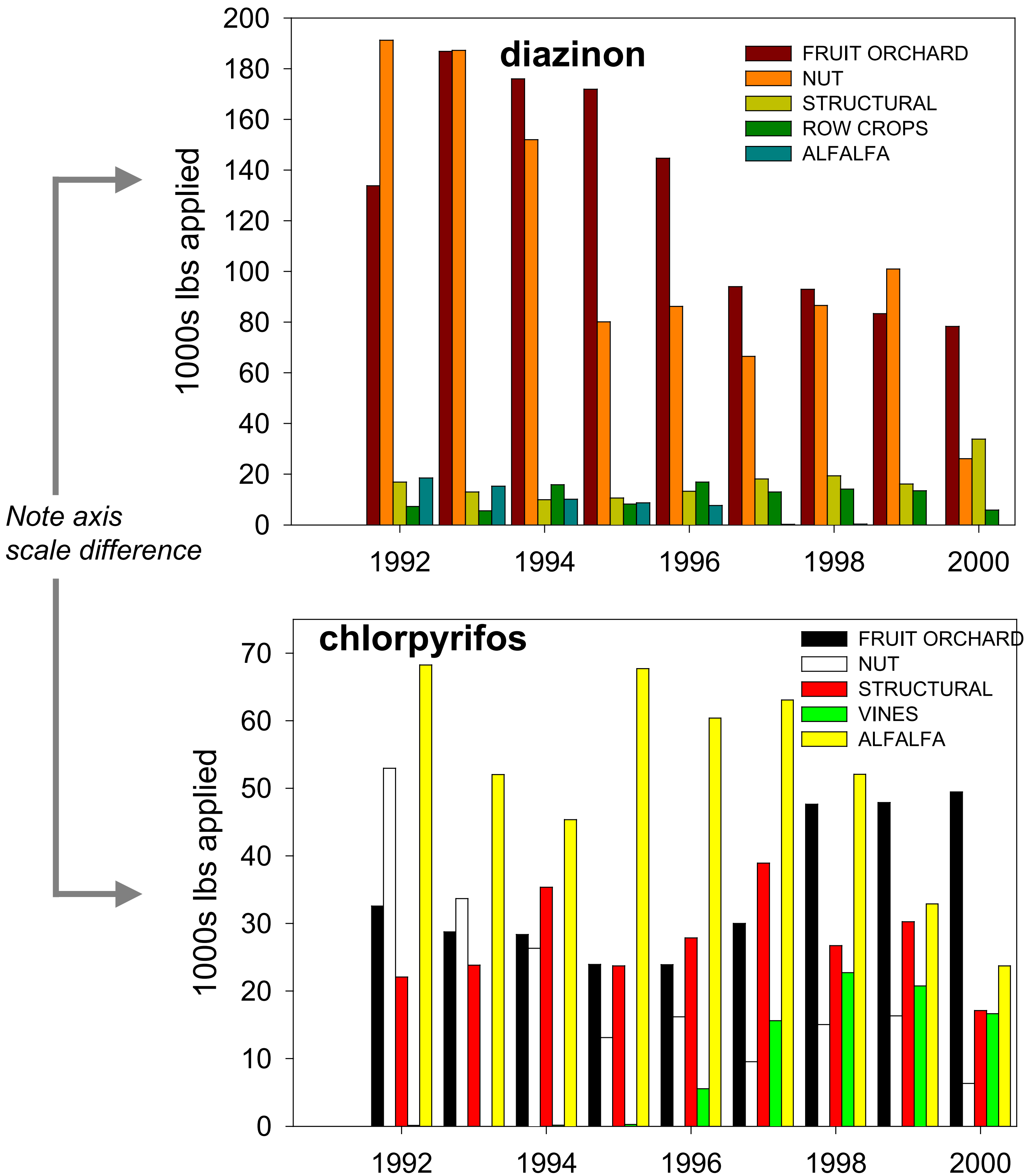


Figure 11. 1998-2000 diazinon use in Sacramento and San Joaquin River Basins. Crop types discussed in text.

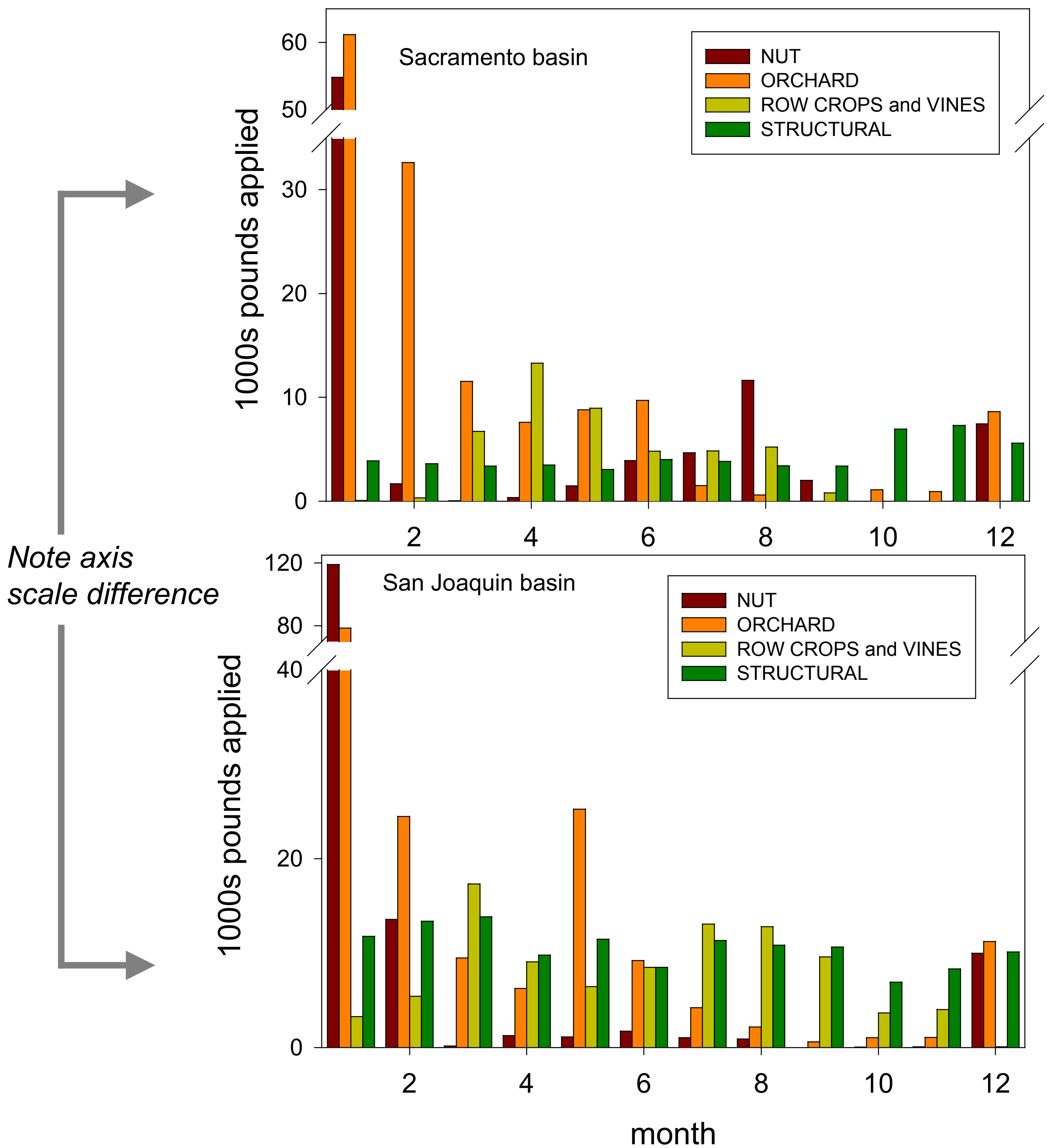


Figure 12. 1998-2000 chlorpyrifos use in major Sacramento and San Joaquin River Basin sites. Crop types discussed in text.

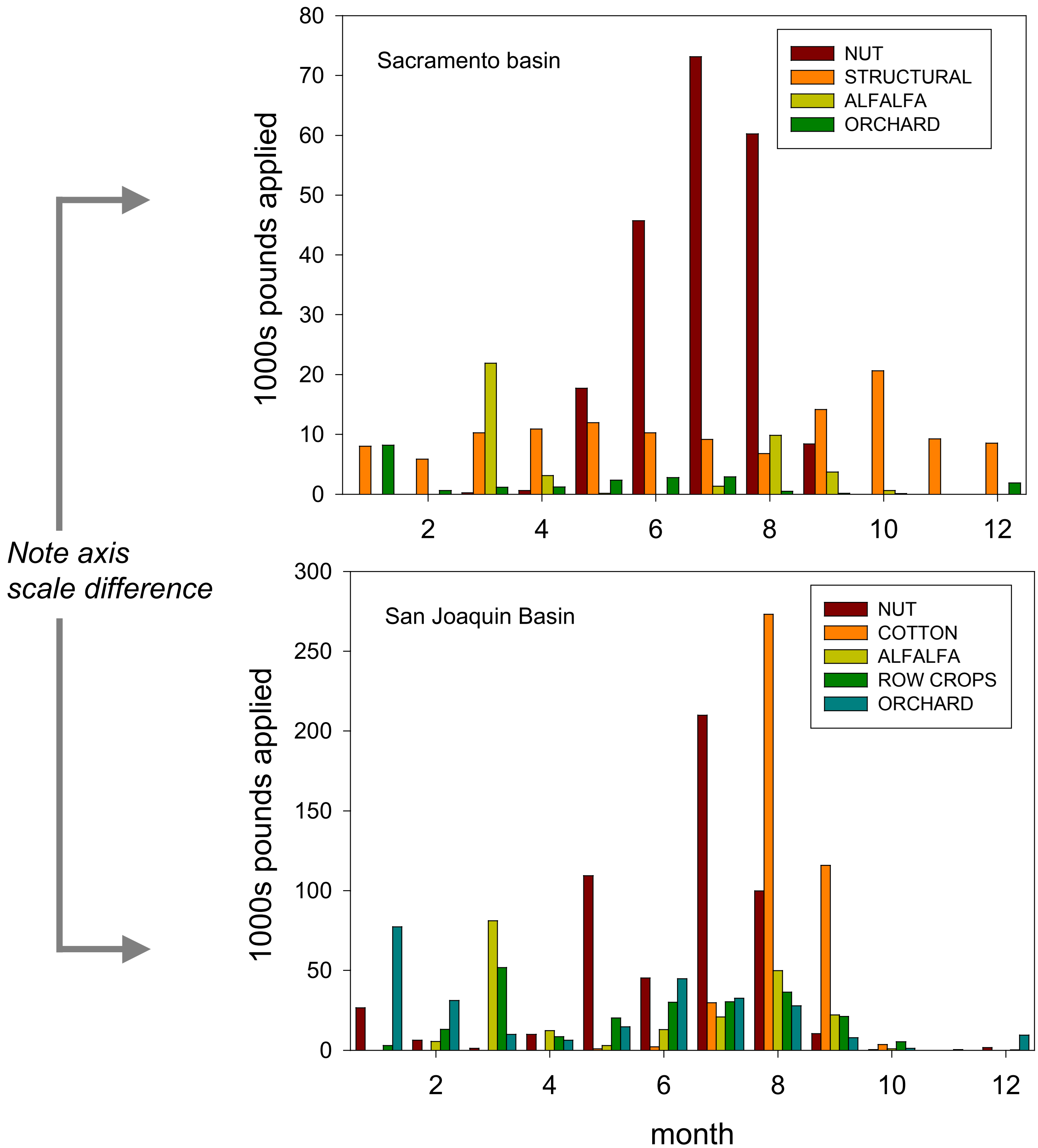


Figure 13 Distribution of diazinon concentrations in river and tributary sampling sites

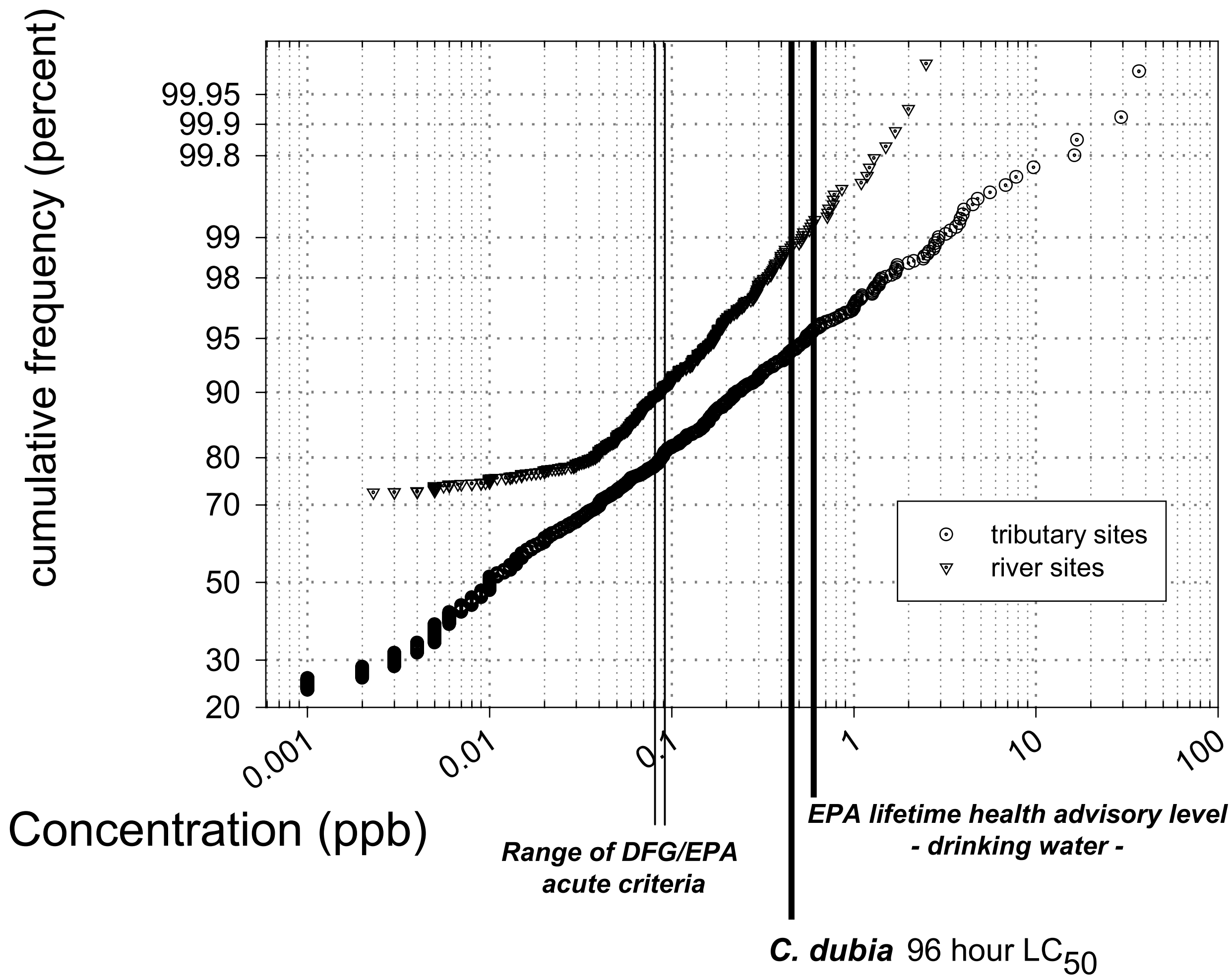


Figure 14. Distribution of chlorpyrifos concentrations in river and tributary sampling sites

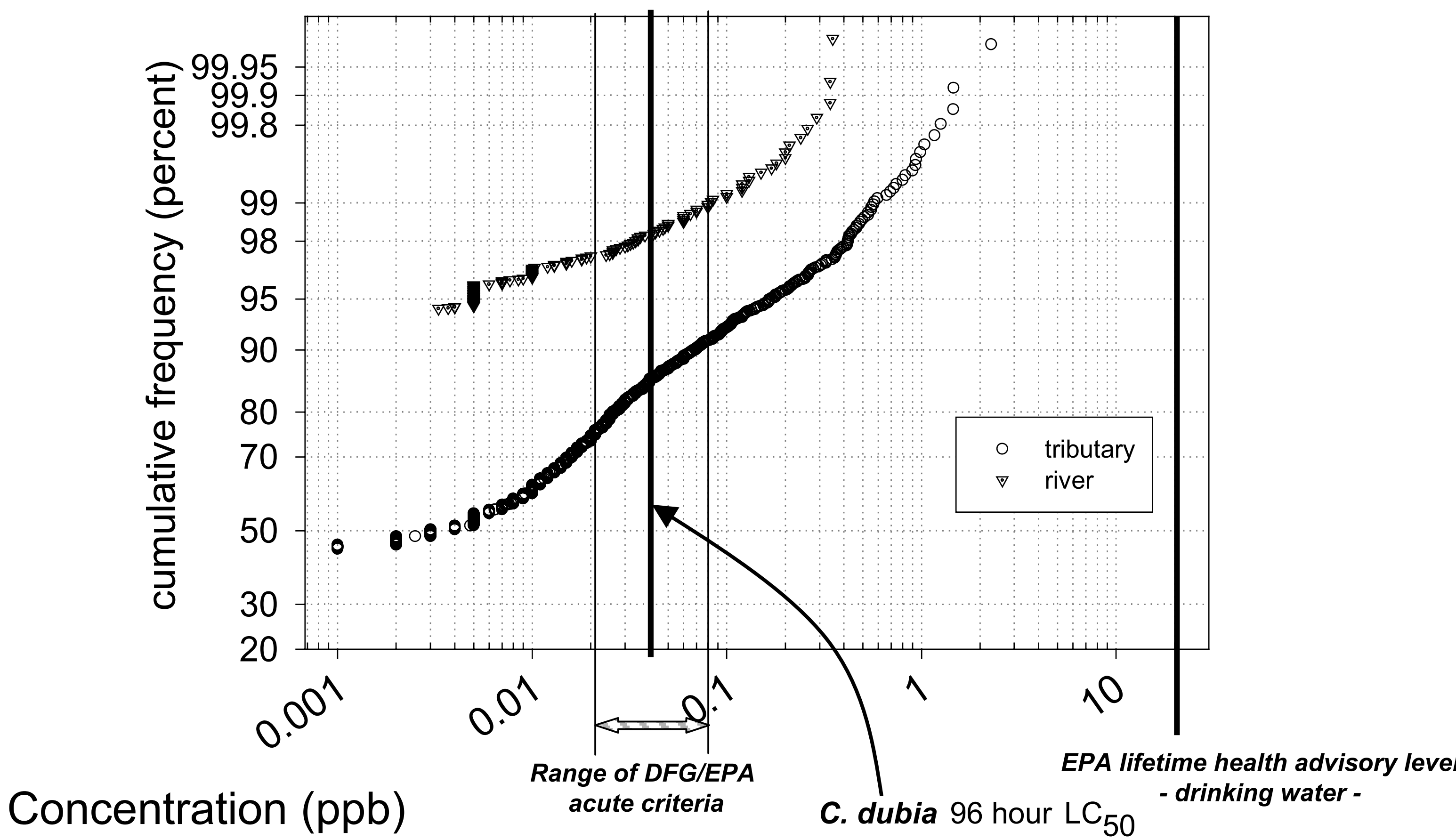


Figure 15. Diazinon monitoring results from
DPR's 5-year dormant spray monitoring program, 1997 – 2001
(Studies 32, 33,37, 38, 57, 58, 62, 63, 99, 00).

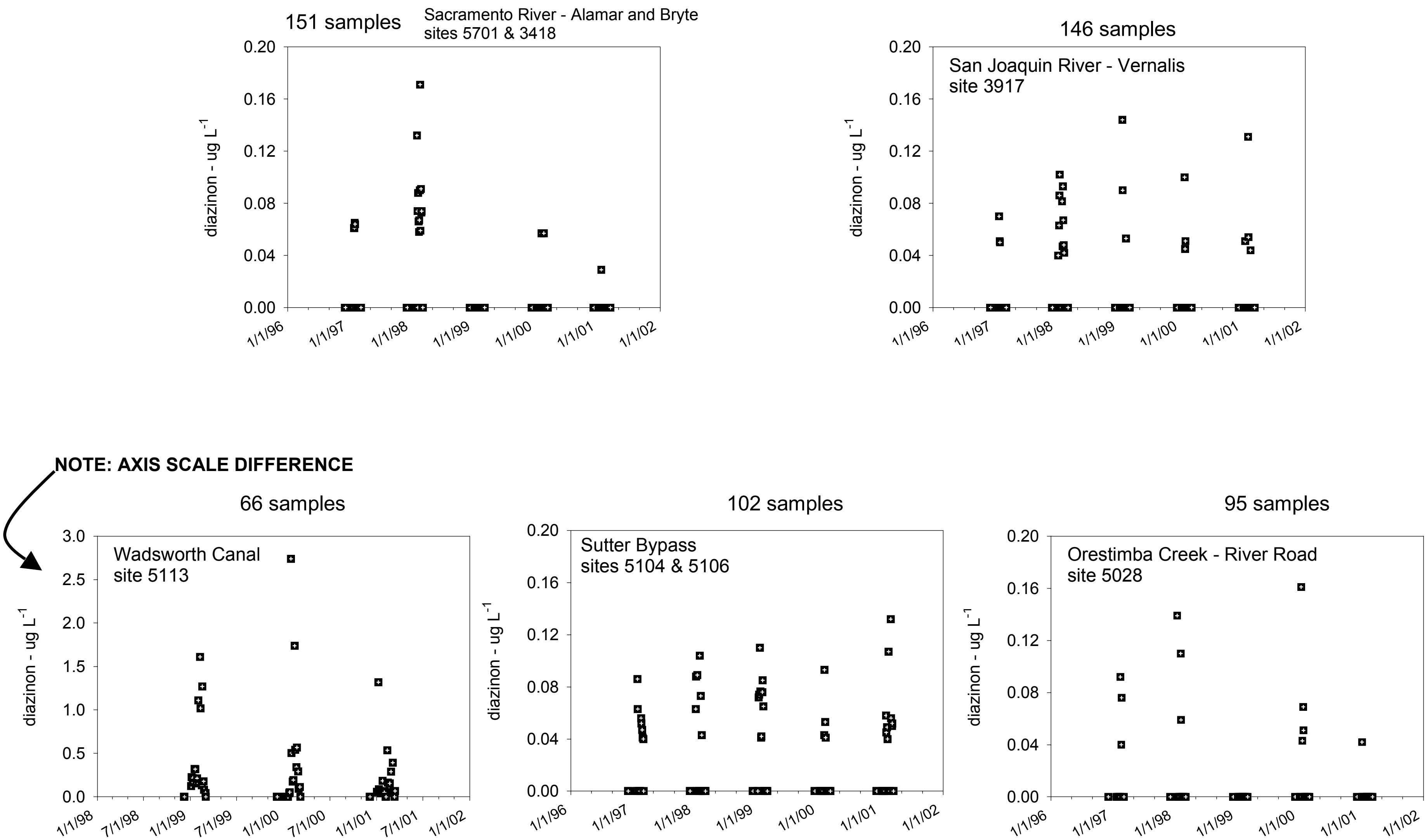
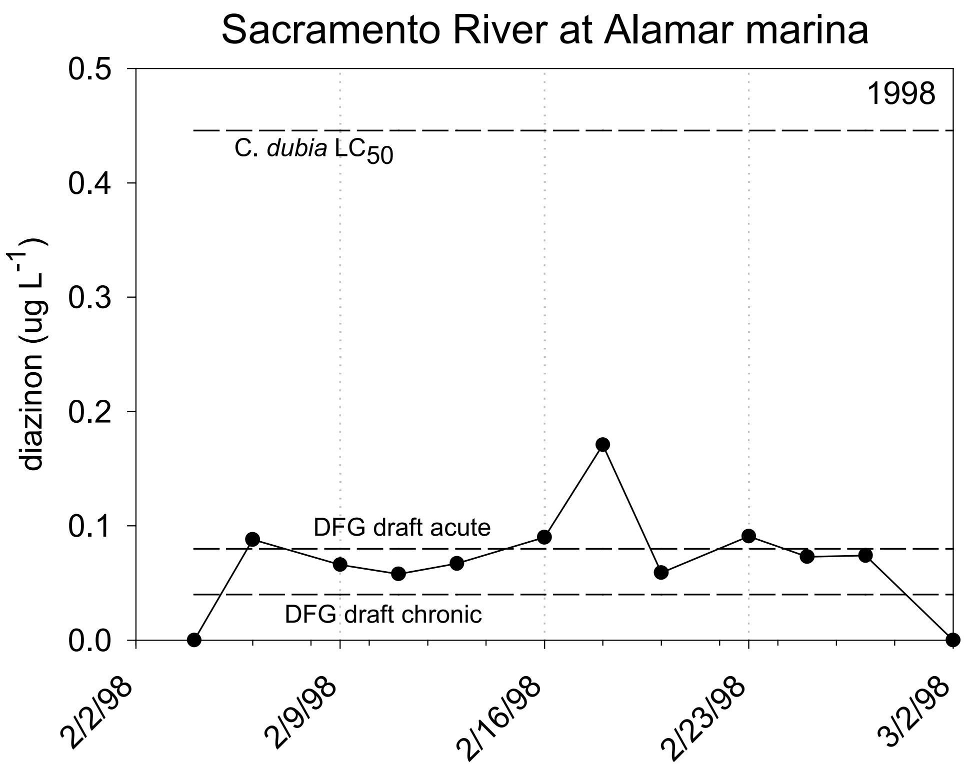


Figure 16. The highest diazinon concentrations measured in the Sacramento and San Joaquin Rivers during DPR's dormant spray monitoring program (1997 – 2001).



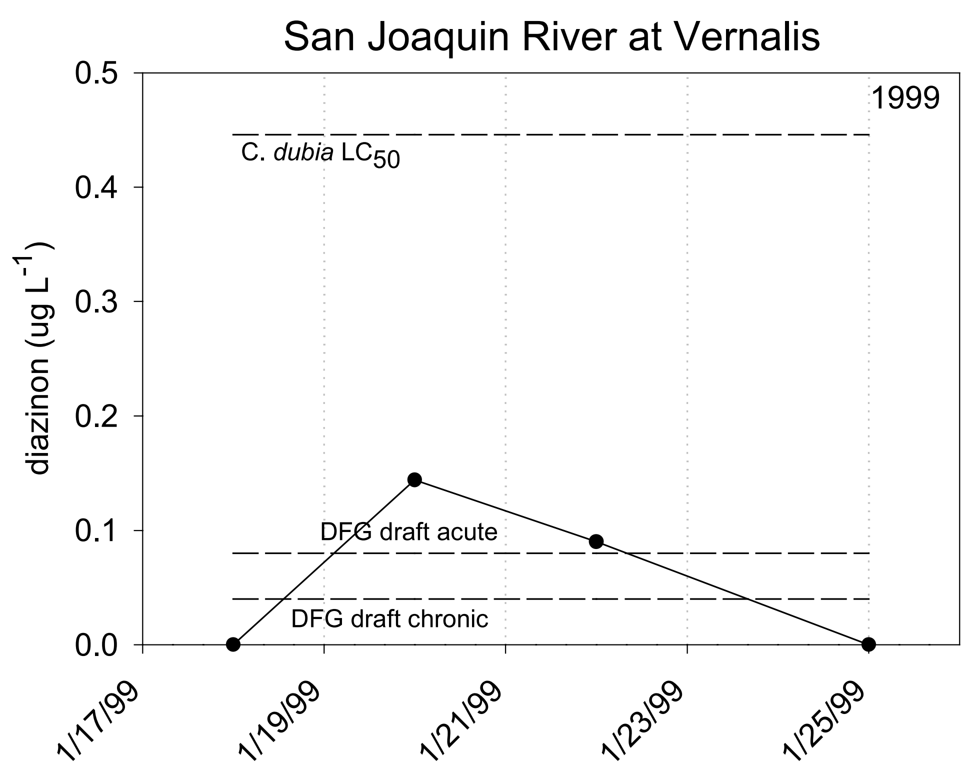
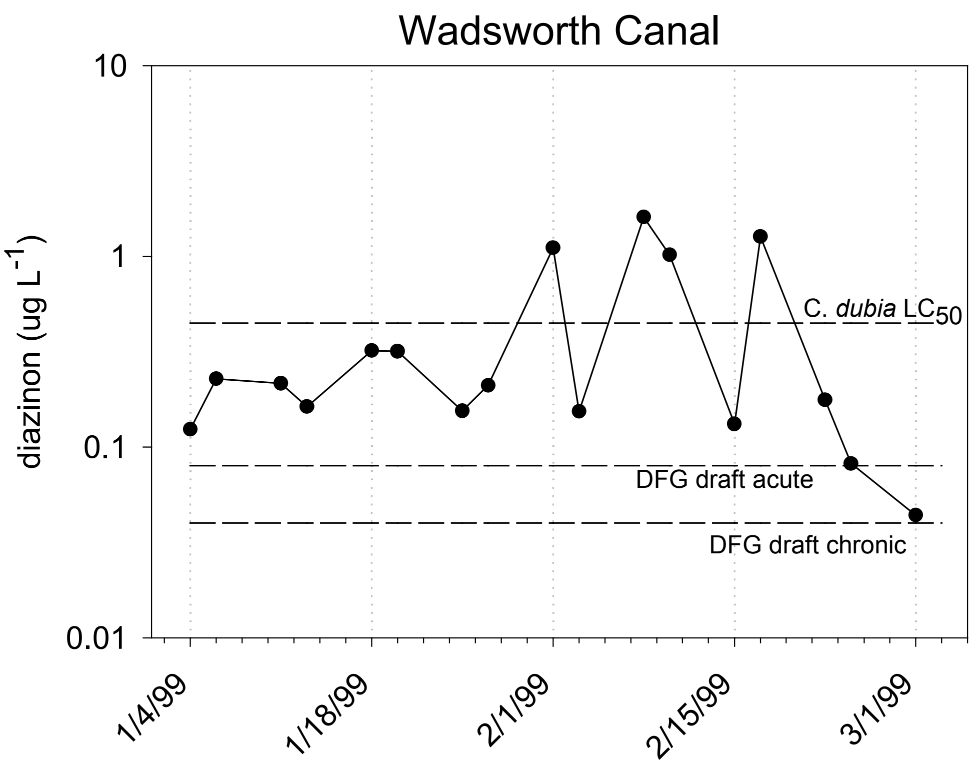


Figure 17. Recent "high" concentration diazinon detections at Wadsworth Canal, Butte County. Note logarithmic concentration scale.



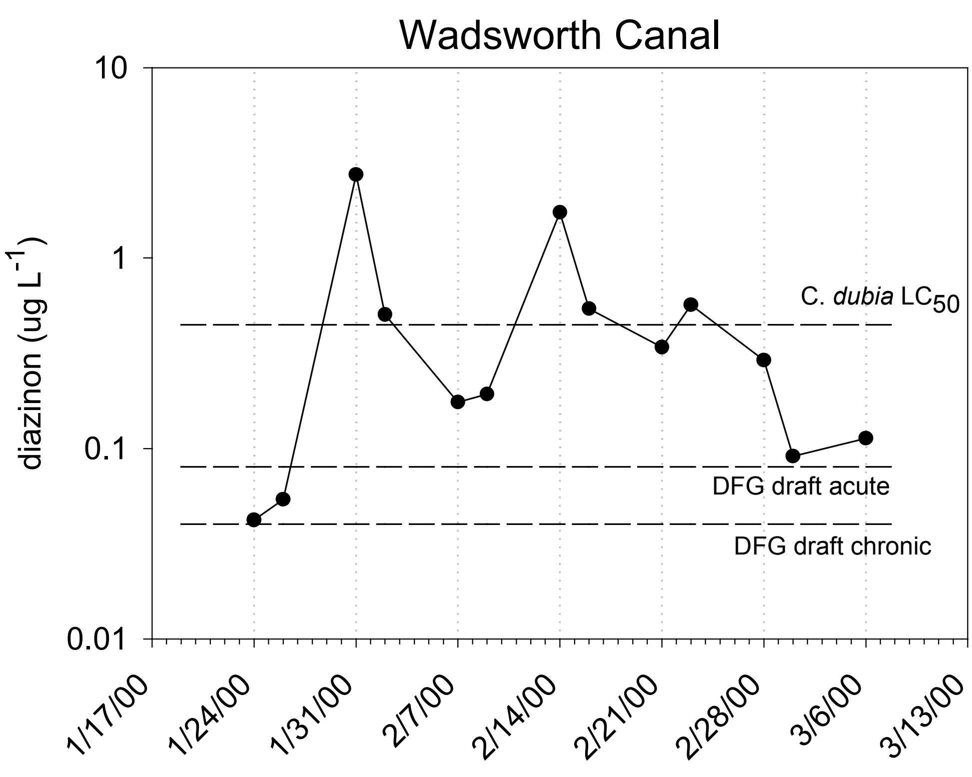
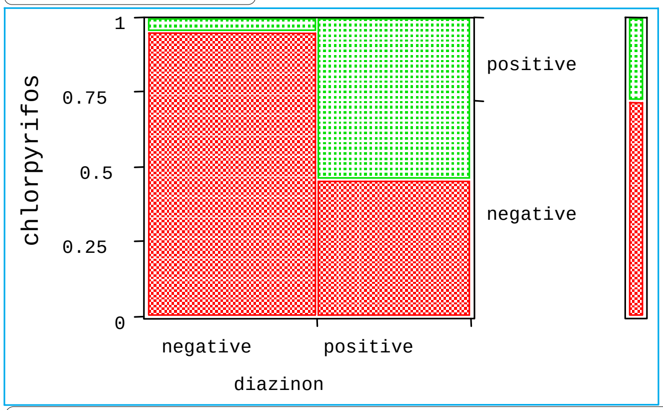


Figure 18. Analysis of diazinon/chlorpyrifos co-occurrence data: Mosaic plot, crosstabs table and test table.

chlorpyrifos By diazinon



Crosstabs

chlorpyrifos by diazinon

Count Total % Row % Col %	negative	positive	
negative	1871 50.35 69.74 95.51	812 21.85 30.26 46.22	2683 72.20
positive	88 2.37 8.52 4.49	945 25.43 91.48 53.78	1033 27.80
	1959 52.72	1757 47.28	3716

Tests

Source	DF	-LogLikelihood	RSquare (U)
Model	1	624.4474	0.2843
Error	3714	1571.8651	
C Total	3715	2196.3126	
Total Count	3716		

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	1248.895	<.0001
Pearson	1121.314	<.0001

Fisher's Exact Test	Prob
Left	1.0000
Right	<.0001
2-Tail	<.0001

conditional frequency (%) of samples being positive for chlorpyrifos given that they are positive for diazinon =

freq (chlorpyrifos = P) | = 54%

freq (chlorpyrifos = P) | diazinon = N = 4%

freq (diazinon = P) | chlorpyrifos = P = 91%

Figure 19. Plot of diazinon concentration vs. chlorpyrifos concentration vs. observed *C. dubia* mortality in 488 surface water samples. The data points are displayed in 3 classes using different colors for each class. The data classes represent the value of calculated TU (toxic units) in each sample. The TU for each sample was calculated from OP concentrations using equation 2. The TU are the predicted C. dubia toxicity (LC_{50} equivalents) based on measured concentrations and laboratory detemined LC_{50}s.

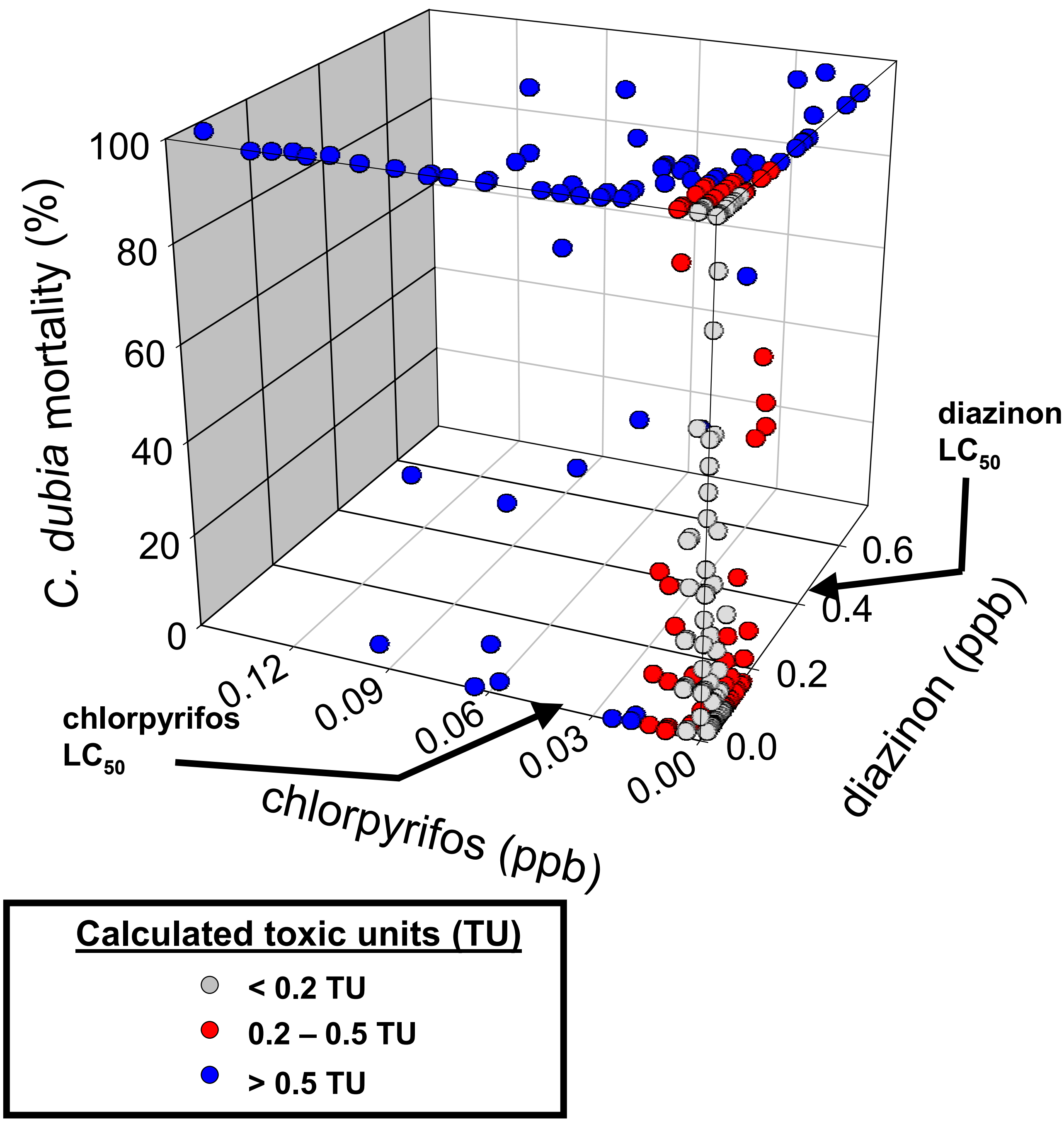
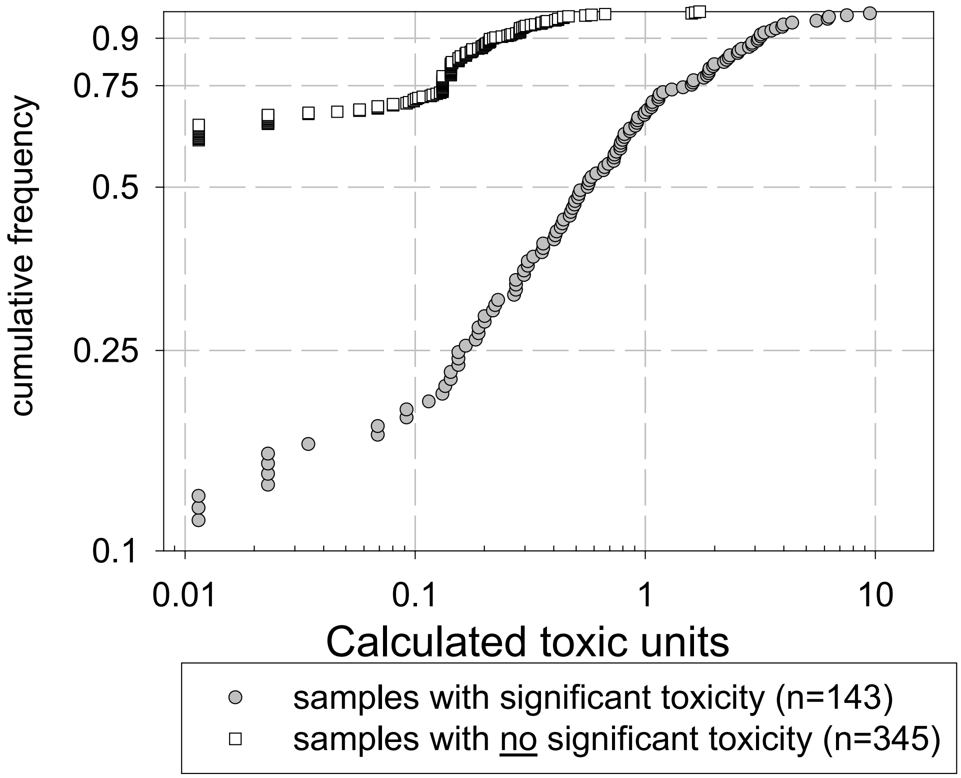


Figure 20. Distribution of calculated toxic units for samples that did and did not display significant toxicity to C. *dubia*



Mood median test: toxic units(TU) in significantly toxic vs nontoxic samples

H_0: median TU for samples with significant toxicity is equal to median TU for samples with no significant toxicity

H_1: median TUs for the two groups are not equal

Chi-Square = 104.83   DF = 1   P = 0.000

```
significant toxicity                                 Individual 95.0% CIs
observed?   N<=    N>   Median    Q3-Q1  +---------+---------+---------+------
No          231   114    0.000    0.132  +
Yes          23   120    0.561    1.436                 (----+--------)
                                         +---------+---------+---------+------
                                       0.00      0.25      0.50      0.75
```

Overall median = 0.023

A 95.0% CI for median(No) - median(Yes): (-0.736,-0.436)

⑧ **Reject H_0,** median toxic units significantly different

Figure 21. Comparison of observed vs predicted toxicity from chlorpyrifos and diazinon for 488 samples.

Significant toxicity defined as (sample – control) mortality ≥ 30 percent

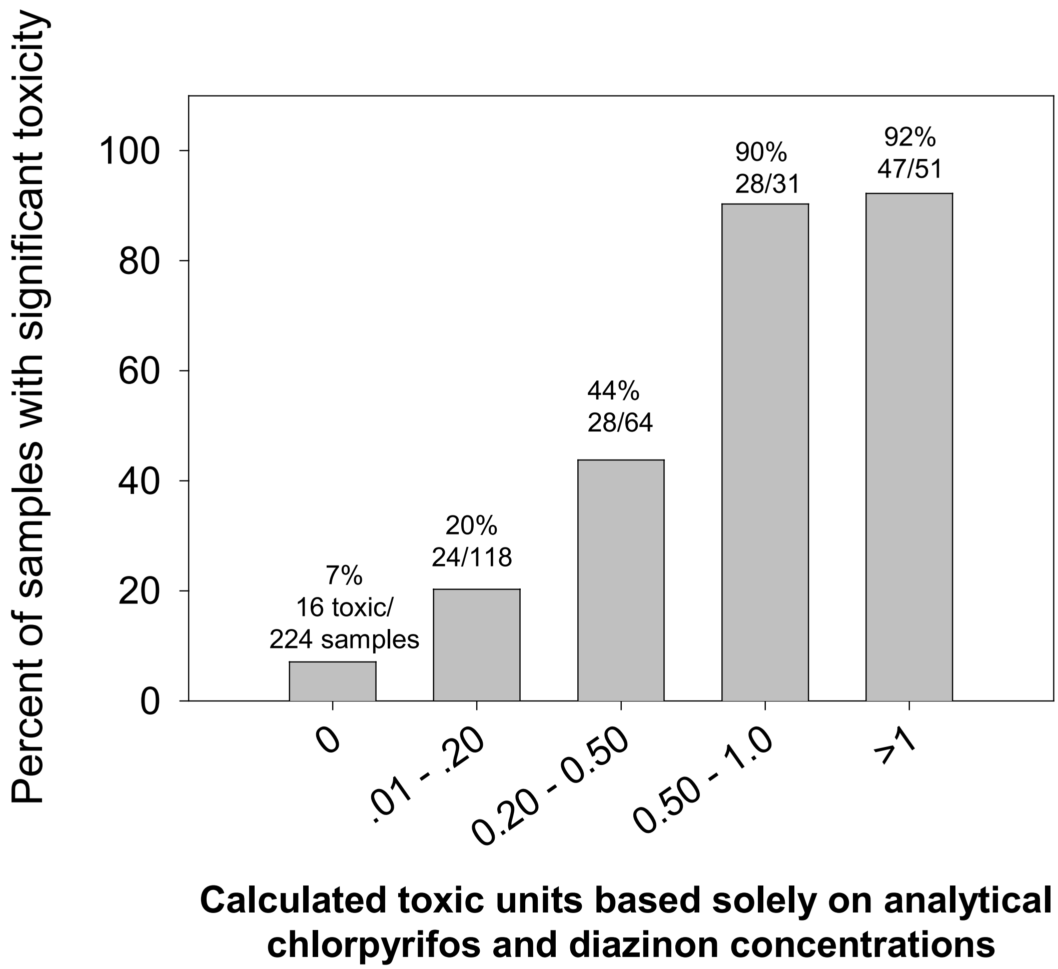
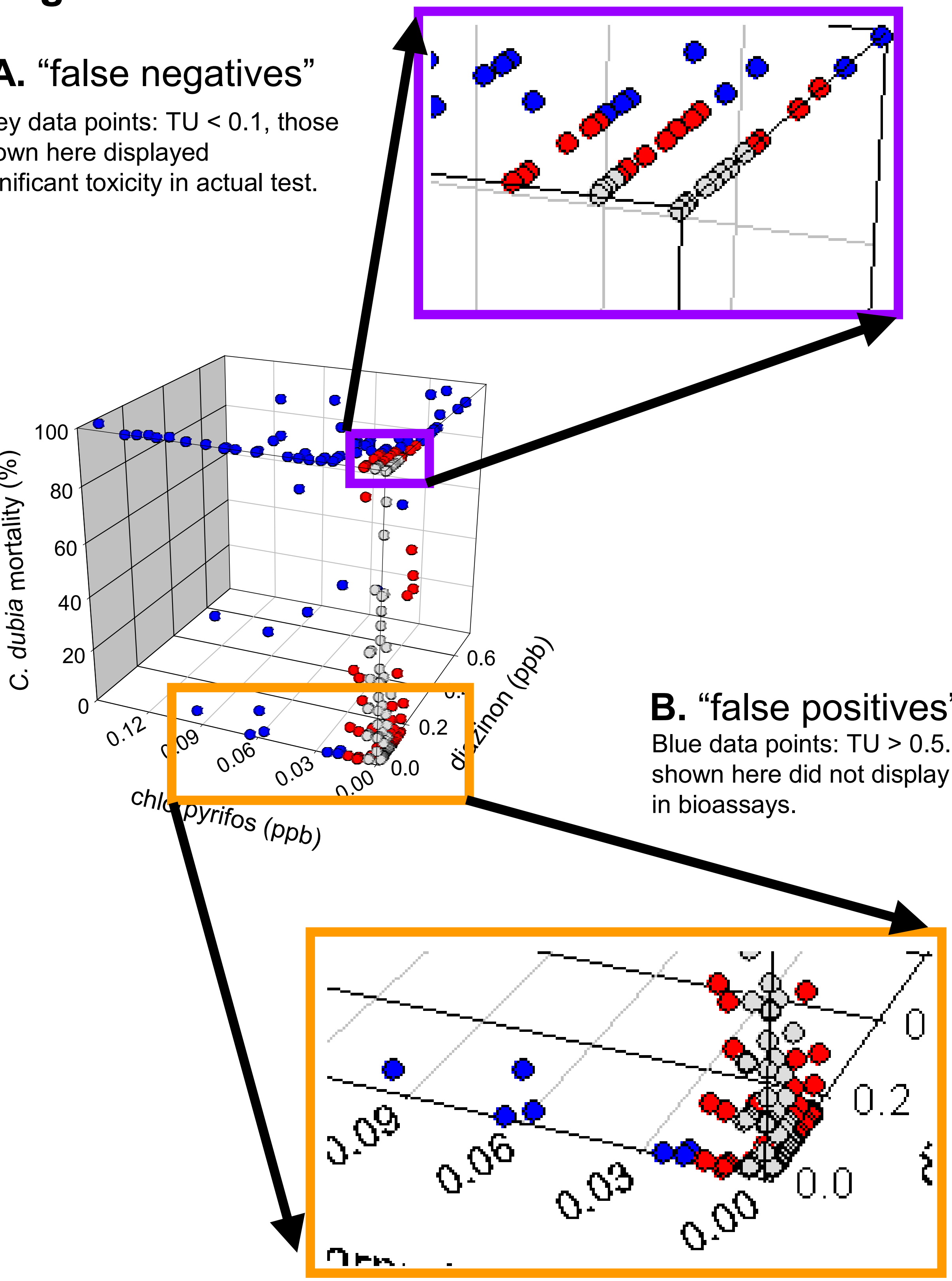


Figure 22.

A. "false negatives"

Grey data points: TU < 0.1, those shown here displayed significant toxicity in actual test.



B. "false positives"

Blue data points: TU > 0.5., those shown here did not display toxicity in bioassays.

Figure 23. Diazinon sampling results for Vernalis, San Joaquin River and River Road, Orestimba Creek. Note year-round sampling during early 1990s in contrast to recent sampling Dec – Mar only

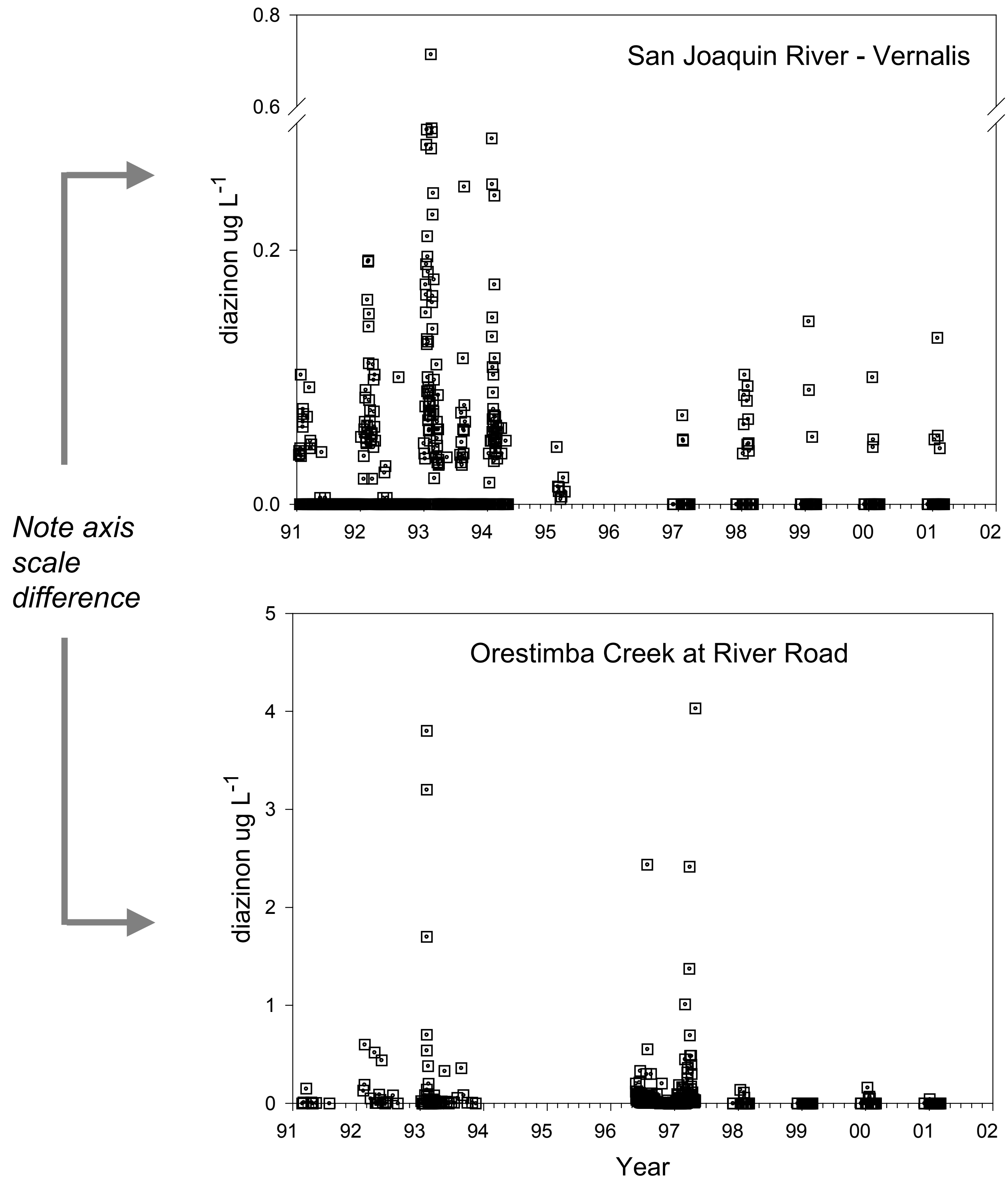


Figure 24. San Joaquin River, Vernalis and Orestimba Creek, River Road detection-limit censored Dec-Mar sampling for diazinon by dormant spray year (censoring threshold = 0.04 ug/L)

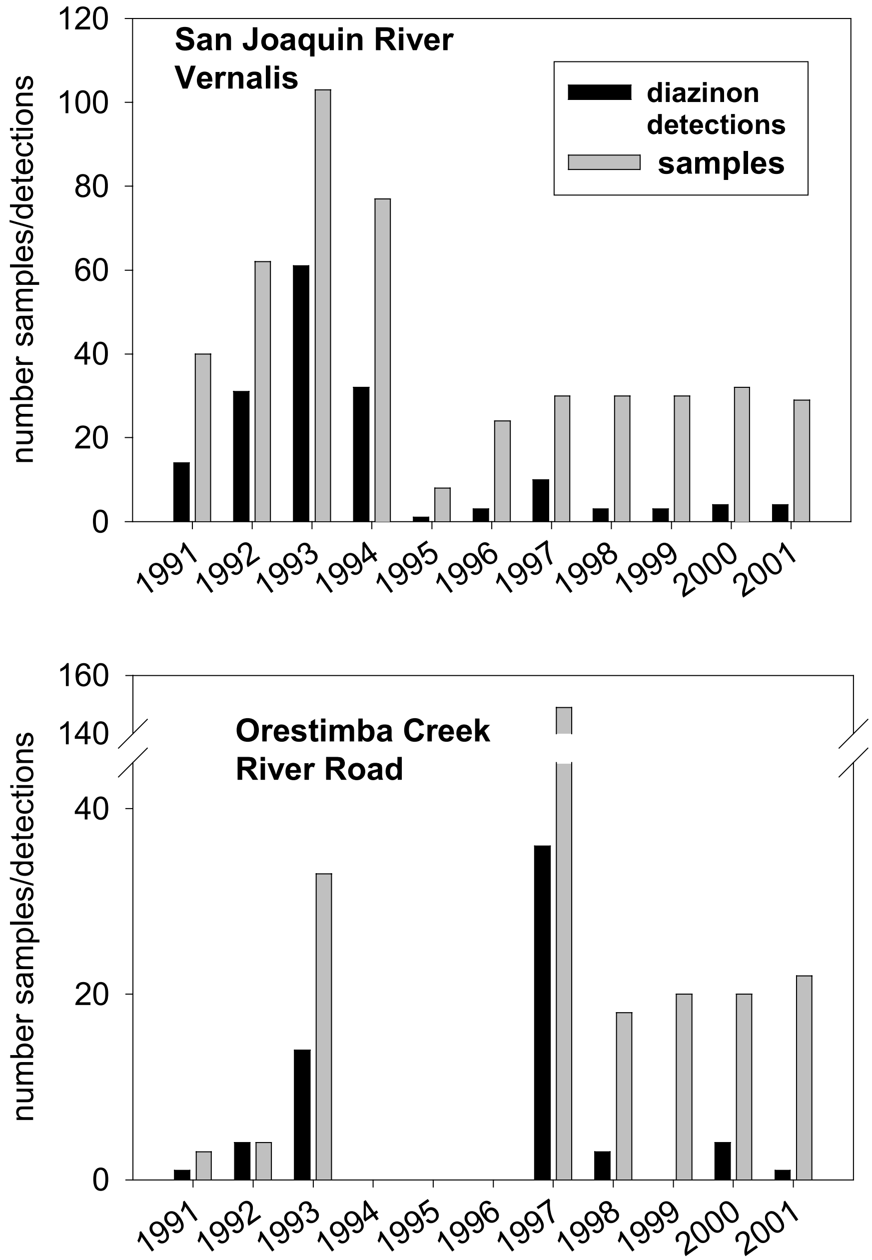
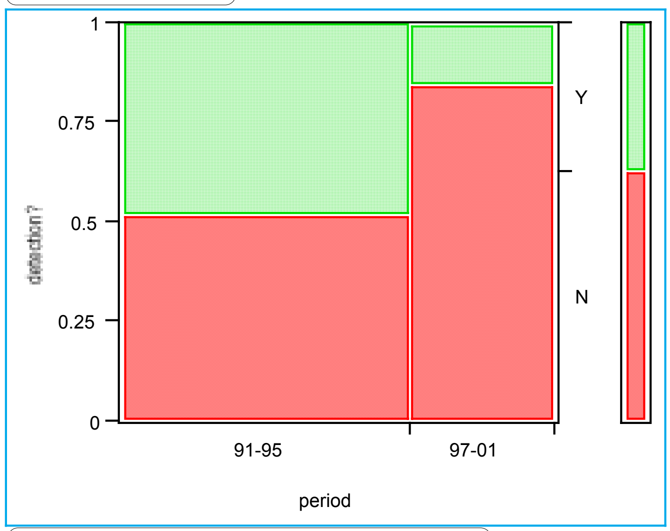


Figure 25. Comparison of winter (censored) diaiznon detection frequencies: Vernalis, San Joaquin River; 91-95 vs 97-01

detection? By period



Crosstabs

period

detection?	Count / Total % / Row % / Col %	91-95	97-01	
	N	151 34.63 55.11 52.07	123 28.21 44.89 84.25	274 62.84
	Y	139 31.88 85.80 47.93	23 5.28 14.20 15.75	162 37.16
		290 66.51	146 33.49	436

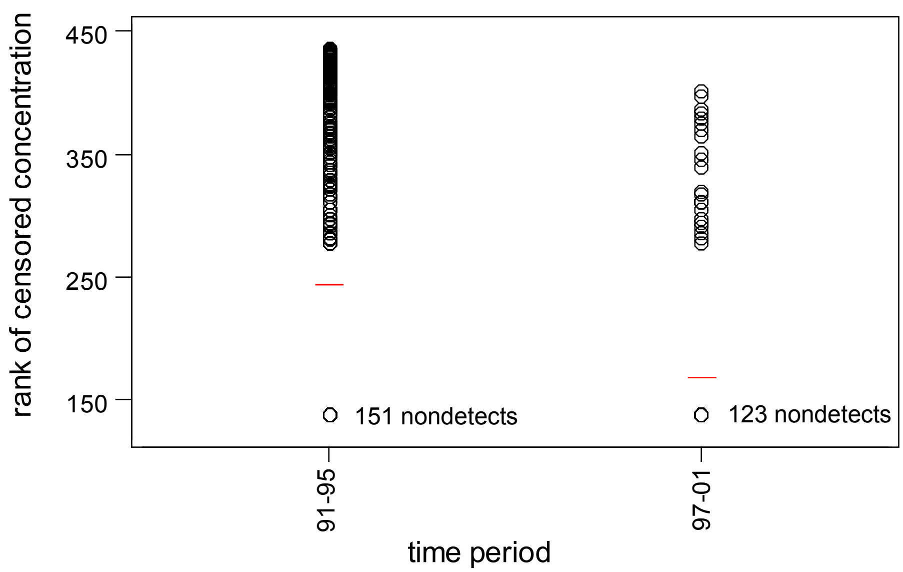
Tests

Source	DF	-LogLikelihood	RSquare (U)
Model	1	23.30845	0.0810
Error	434	264.35586	
C Total	435	287.66431	
Total Count	436		

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	46.617	<.0001
Pearson	43.061	<.0001

Fisher's Exact Test	Prob
Left	<.0001
Right	1.0000
2-Tail	<.0001

Figure 26. Nonparametric analysis of variance on ranks to test for effect of time period on Vernalis censored diazinon concentrations. December – March data only.



Analysis of Variance for <u>rank of censored diazinon concentration</u> by time period

H_0: mean $rank_{97\text{-}01}$ = mean rank $_{91\text{-}95}$ vs H_1: 97-01 and 91-95 mean ranks are not equal

VERNALIS, SAN JOAQUIN RIVER

Source	DF	SS	MS	F	P
period	1	548082	548082	51.22	**0.000**
Error	434	4644356	10701		
Total	435	5192439			

```
                         Individual 95% CIs For Mean Rank
                         Based on Pooled StDev
Level    N    Mean   StDev   ----------+---------+---------+------
91-95   290   243.7  115.5                            (---*---)
97-01   146   168.5   73.7   (----*-----)
                             ----------+---------+---------+------
Pooled StDev =  103.4              180       210       240
```

Fisher's pairwise comparisons

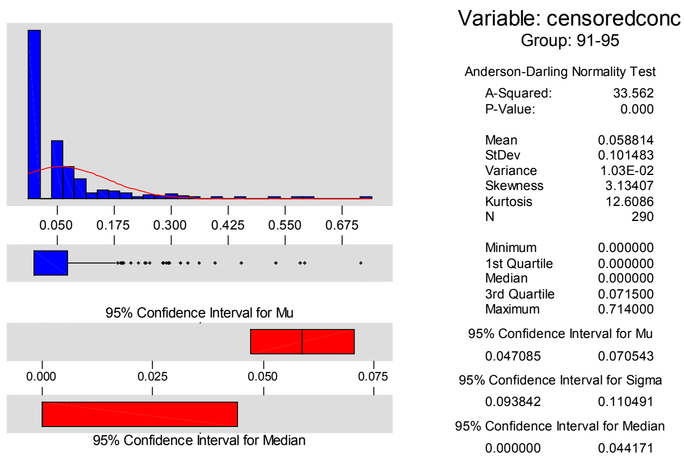
Individual error rate = 0.0500

Critical value = 1.965

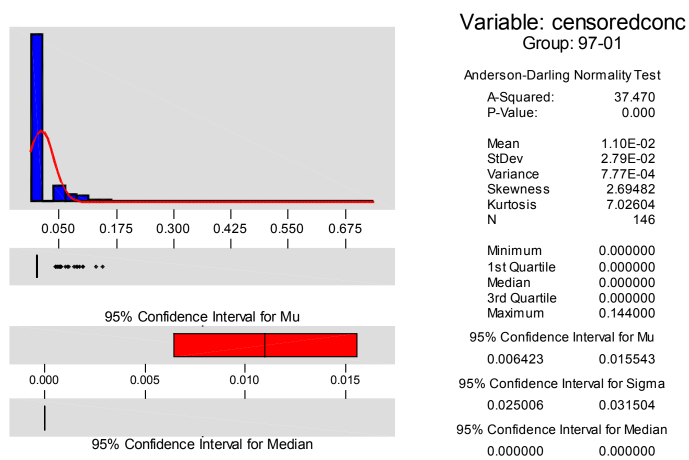
95% CI for [(91-95 mean rank) - (97-01 mean rank)] = (55, 96) , reject H_0

Figure 27. Descriptive statistics and cumulative frequency plot for 91-95 and 97-01 diazinon sampling at Vernalis

Descriptive Statistics: 91-95 diazinon Vernalis



Descriptive Statistics: 97-01 diaiznon Vernalis



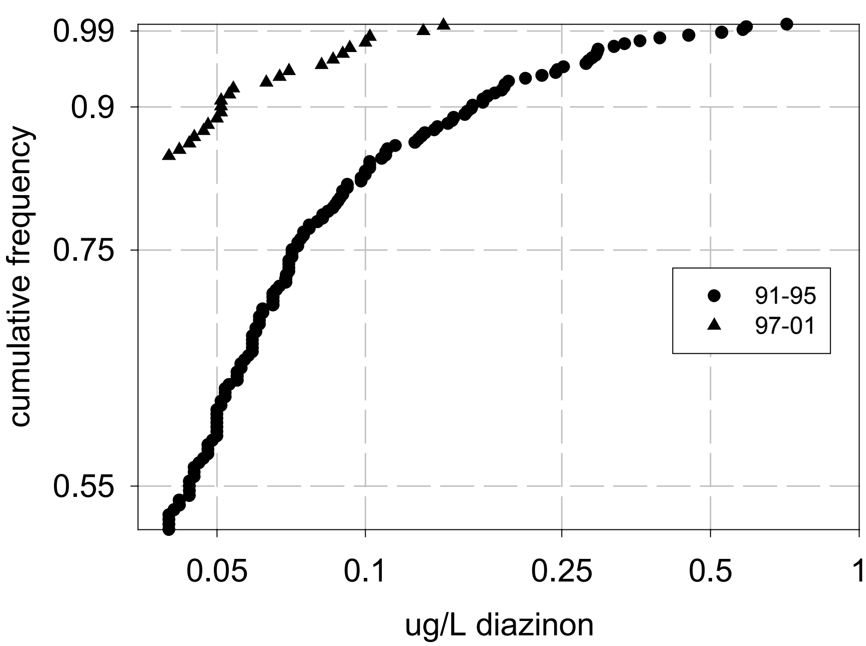
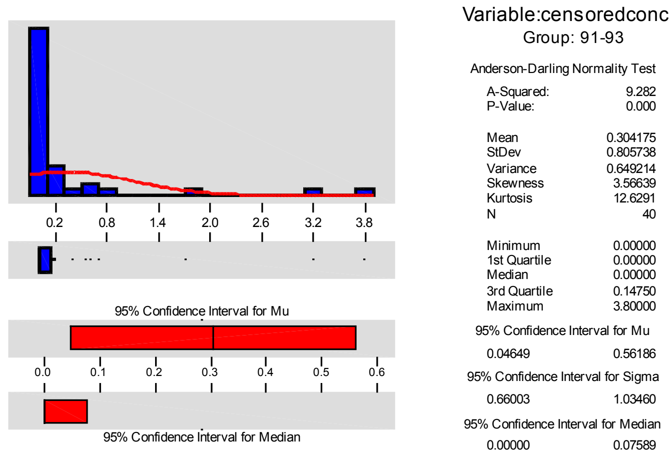
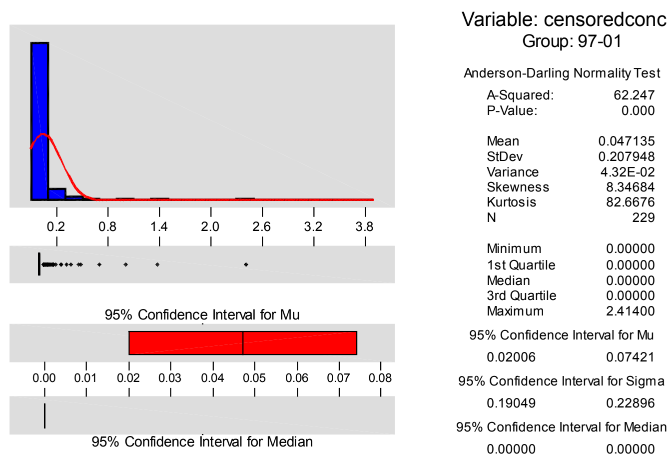


Figure 28. Descriptive statistics and cumulative frequency plot for 91-95 and 97-01 diazinon sampling at Orestimba Creek, River Road

Descriptive Statistics: 91-93 Orestimba Creek



Descriptive Statistics: 97-01 Orestimba Creek, River Road



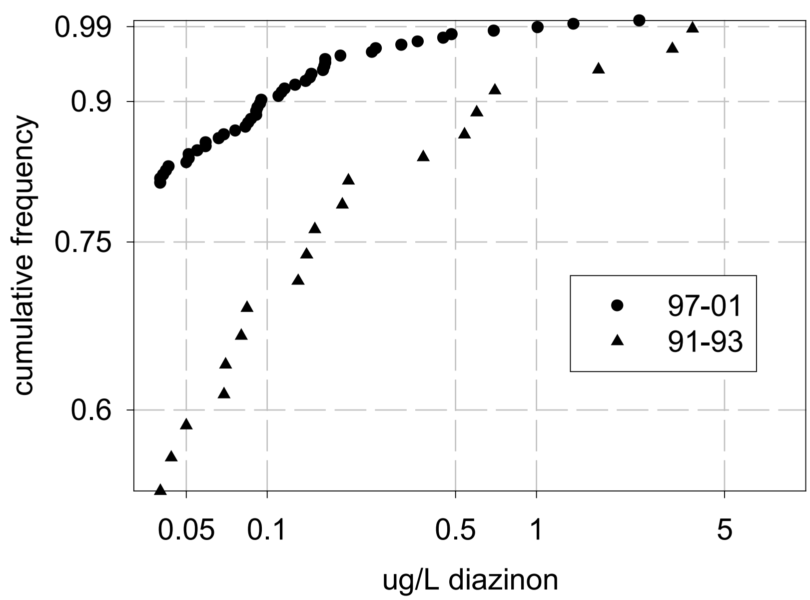
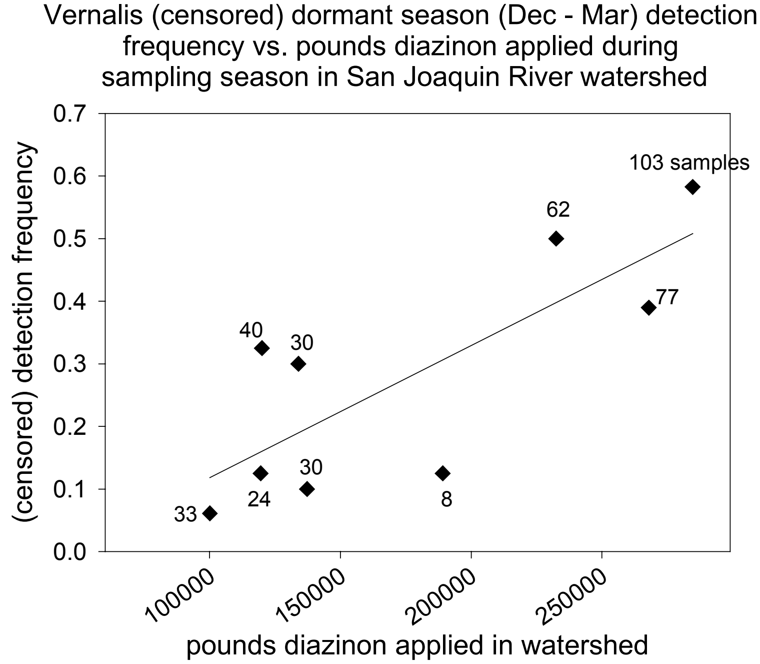


Figure 29. Relationship between winter diazinon use and censored detection frequency (censoring threshold = 0.04) at Vernalis



(Dec-Mar)	lbs applied	detect. freq.	no samples
1991	119970	0.33	40
1992	232496	0.50	62
1993	284665	0.58	103
1994	267927	0.39	77
1995	189119	0.13	8
1996	174053	----	0
1997	119493	0.13	24
1998	133944	0.30	30
1999	137243	0.10	30
2000	100101	0.10	30

Regression Analysis: censored diazinon detection frequency vs lbs diazinon applied

Weighted analysis using weights = number of samples

The regression equation is

freq = - 0.058 +0.000002 lbs

Predictor	Coef	StDev	T	P
Constant	-0.0579	0.1066	-0.54	0.604
lbs	0.00000211	0.00000049	4.28	**0.004**

S = 0.7237 **R-Sq = 72.4%**

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	9.6027	9.6027	18.33	**0.004**
Residual Error	7	3.6663	0.5238		
Total	8	13.2690			

Appendix 1. Summary of source studies for diazinon and chlorpyrifos data.

APPENDIX 1

UNITED STATES GEOLOGICAL SURVEY (9): “Dissolved pesticide data for the San Joaquin River at Vernalis and the Sacramento River at Sacramento, California, 1991-94” by D. MacCoy, K.L. Crepeau, and K.M. Kuivila, open-file report 95-110, 1995. 19,118 records; no biotoxicity monitoring; no water quality data. Samples were collected daily or every other day from May 1991 through April 1994 at Sacramento and from January 1991 through April 1994 at Vernalis, filtered, and analyzed by GC/MS for a total of 23 active ingredients and breakdown products. A total of 7 compounds were detected at Sacramento; a total of 13 compounds were detected at Vernalis. Detections reported to DPR below the LOQ were entered into the database as zero. QA/QC information given in report and in USGS open-file report 94-362. Data entered from hard-copy report and Excel data files.

DEPARTMENT OF PESTICIDE REGULATION (10): “Distribution and mass loading of insecticides in the San Joaquin River, California: spring 1991 and 1992” by L.J. Ross, R. Stein, J. Hsu, J. White, and K. Hefner, DPR report EH 99-01,1999; “Distribution and mass loading of insecticides in the San Joaquin River, California: winter 1991-92 and 1992-93” (DPR report EH 96-06) by L.J. Ross, R. Stein, J. Hsu, J. White, and K. Hefner, 1996; four memoranda by L. Ross (DPR), and six memoranda by R. Fujumura (DFG). 10,955 pesticide analysis records, 204 biotoxicity test result measurements, water quality data reported. Water samples were collected from the San Joaquin River at Laird Park seasonally from 1991 through 1993. Lagrangian samples were also taken from 23 tributary inputs to monitor mass loading. Samples were analyzed for a total of 37 active ingredients and breakdown products. Overall, a total of 22 active ingredients and breakdown products were detected. Acute toxicity tests were conducted on *C. dubia* and *N. mercedis* by Department of Fish and Game Aquatic Toxicology Laboratory. Significant mortality was seen in 31 of the 204 bioassay measurements. Ratio of biotoxicity test samples analyzed for pesticides = 1:1. Continuing quality control summaries and blind spike results given in reports; QA/QC statement given in memoranda. Data entered from raw data sheets.

SWRCB (13): “Colorado River Basin Toxicity Report, Draft Final, March 1993 through February 1994” prepared for V. de Vlaming and G. Starrett, SWRCB; prepared by C. DiGiorgio, H.C. Bailey, and D.E. Hinton, UCD, Interagency Agreement 0-149-250-0. 4,997 chemical analyses. Samples were collected twice a month from 11 fixed sampling sites on the Alamo River. Samples were analyzed for 73 compounds, 22 were detected. Biotoxicity monitoring and TIE results will be entered as time allows; no water quality data. Some QA/QC information included in report; data entered from hard-copy report.

DEPARTMENT OF PESTICIDE REGULATION (14): “Temporal distribution of insecticide residues in four California Rivers” by C. Ganapathy et al., DPR report EH 97-06, 1997. 8,481 pesticide analysis records, 191 biotoxicity test result measurements, water quality data reported. Water samples were collected weekly from the Salinas and Russian rivers from August 1994 through August 1995, from the Sacramento River from November 1993 through November 1994, and the Merced River from June 1994 through June 1995. The samples were analyzed by GC/FPD, HPLC/PCDFD, GC/ECD, or GC/NPD for 37 compounds. Chlorpyrifos, diazinon, dimethoate, methidathion, and 3-hydroxycarbofuran were detected. Acute toxicity tests were conducted on *Ceriodaphnia dubia* and

Pimephales promelas by Department of Fish and Game Aquatic Toxicology Laboratory. Significant mortality was seen in 3 of the 191 bioassay tests. Ratio of pesticide analysis samples to biotoxicity testing samples = 1:1. Method validation information and continuing quality control summary given in report. Data entered from raw data sheets.

<u>DEPARTMENT OF PESTICIDE REGULATION (32)</u>: "Occurrence of aquatic toxicity and dormant-spray pesticide detections in the San Joaquin River watershed, winter 1996-97" by K.P.Bennett, et al., 1998. 430 pesticide analysis records, 88 biotoxicity test result measurements, water quality data reported. Water samples were taken from a site on the main stem San Joaquin River and a site on Orestimba Creek, a tributary to the San Joaquin, during December 1996 to March 1997. Samples were analyzed by GC/FPD or HPLC/PCDFD for 10 pesticide active ingredients. Diazinon was detected at both sites. Dimethoate and carbofuran were also detected at Orestimba Creek. Acute toxicity was tested using *Ceriodaphnia dubia* on samples taken from Orestimba. Chronic toxicity was tested for with *C. dubia* on samples taken from the San Joaquin. Significant biotoxicity was seen in 2 acute samples. Ratio of pesticide analysis samples to acute biotoxicity testing samples = 1:1; ratio of pesticide analysis samples to chronic biotoxicity testing samples = 1:1. Method validation, continuing quality control, and blind spike recoveries are given in report. Data entered from raw data.

<u>DEPARTMENT OF PESTICIDE REGULATION (33)</u>: "Occurrence of aquatic toxicity and dormant-spray pesticide detections in the Sacramento River watershed, winter 1996-97" by C.E. Nordmark, et al. 1998. 440 pesticide analysis records, 90 biotoxicity test result measurements, water quality data reported. Water samples were taken from the Sacramento River at Bryte and Sutter Bypass at Karnak and Kirkville Road during December 1996 to March 1997. Samples were analyzed by GC/FPD or HPLC/PCDFD for 10 pesticide active ingredients. Diazinon was detected in the Sacramento River and Sutter Bypass. Methidathion was also detected in the Sutter Bypass. Significant biotoxicity was not seen in acute or chronic samples. Ratio of pesticide analysis samples to acute and chronic biotoxicity testing samples = 1:1. Method validation, continuing quality control, and blind spike recoveries are given in report. Data entered from raw data.

<u>CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD (35)</u>: "Insecticide concentrations and invertebrate bioassay mortality in agricultural return water from the San Joaquin basin" by C. Foe, 1995. 5,224 pesticide analysis records and 1,732 biotoxicity test result measurements. Acute and chronic toxicity tests on *Ceriodaphnia dubia* were conducted on a total of 573 samples collected weekly from seven sites on the San Joaquin River and 14 of its tributaries from February 1991 through June 1992. Of those samples, 232 were analyzed by HPLC/PCDFD for 23 pesticide active ingredients and breakdown products. A total of 14 compounds were detected. Diazinon was detected at every site; chlorpyrifos was detected at all but one site. 115 bioassay samples showed significant toxicity. Ratio of pesticide analysis samples to biotoxicity testing samples = 1:2.3. QA/QC general information and interlaboratory comparisons given in report. Data entered from hard-copy report.

<u>DEPARTMENT OF PESTICIDE REGULATION (37)</u>: "Preliminary results of acute and chronic toxicity testing of surface water monitored in the Sacramento River watershed, winter 1997-98" by C. Nordmark, 1998. 1,100 pesticide analysis records, 93 biotoxicity test result measurements. Water samples were taken from the Sacramento River at Alamar (Sacramento County) and two sites in the Sutter Bypass from December 1997 through March 1998. The samples were analyzed for 19 pesticide active ingredients. Diazinon and diuron were detected at all 3 sites. Methidathion and simazine were

also detected in the Sacramento River at Alamar. Bromacil and simazine were also detected in Sutter Bypass. Significant biotoxicity was not seen in acute or chronic samples. Ratio of pesticide analysis samples to acute and chronic biotoxicity testing samples = 1:1. Continuing QC results and general QA/QC information are given in the memorandum. Data entered from original COCs.

<u>DEPARTMENT OF PESTICIDE REGULATION (38)</u>: "Preliminary results of acute and chronic toxicity testing of surface water monitored in San Joaquin River watershed, winter 1997-98" by C. Ganapathy, 1999. 1,026 pesticide analysis records, 91 biotoxicity test result measurements. Water samples were taken from the San Joaquin River at Vernalis and Orestimba Creek, a tributary to the San Joaquin, from December 1997 through March 1998 and analyzed for a total of 19 pesticide active ingredients. Bromacil, cyanazine, diazinon, diuron, and simazine were detected at both sites. In addition, methidathion was detected in the San Joaquin River and chlorpyrifos and methyl parathion in Orestimba Creek. Significant mortality was seen in 3 acute samples from Orestimba Creek and 1 chronic sample from the San Joaquin River. Ratio of pesticide analysis samples to acute and chronic biotoxicity testing samples = 1:1. Continuing QC results and general QA/QC information are given in the memorandum. Data entered from original COCs.

<u>UNITED STATES GEOLOGICAL SURVEY (39)</u>: "Transport of diazinon in the San Joaquin River Basin, California" by Charles R. Kratzer, 1997 (USGS National Water-Quality Assessment Program, open-file report 97-411). 92 pesticide analyses; no biotoxicity data. Specific conductance data reported. Nine sites (3 San Joaquin River tributaries and a downstream site and sites on the Merced, Tuolumne, and Stanislaus rivers) were sampled during storms in January and February 1994. Samples were analyzed for diazinon only. Diazinon was detected in every sample. Concentrations ranged from .004 to 2.9 ppb; average concentration 0.26. QA/QC and MDL details given in report. Data downloaded from NAWQA website. Originals at USGS.

<u>UNITED STATES GEOLOGICAL SURVEY (41)</u>: "Pesticide monitoring in the Sacramento River Basin for the USGS National Water Quality Assessment Program" by J. Domagalski, in prep. 6545 pesticide analysis records; no biotoxicity data; no water quality data. Samples were taken from the Sacramento River at Freeport, Arcade Creek, the Feather River, and Colusa Basin Drain at Knights Landing during 1996-98 and analyzed for a total of 85 pesticides; 43 were detected. Data sent on hard-copies (J. Domagalski, personal communication). Detections below the RPL were entered as zero. NAWQA QA/QC is well documented. Report in preparation.

<u>CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD (43)</u>: "Pesticides in surface water from applications on orchards and alfalfa during the winter and spring 1991-92" by C. Foe and R. Sheipline, February 1993. Eleven orchard sites in the Sacramento and San Joaquin River watersheds and 13 alfalfa sites in the Delta Estuary were monitored weekly in spring 1992. Acute and chronic *Ceriodaphnia dubia* bioassays were performed according to USEPA methods. Toxic samples were submitted for pesticide analysis. Data transcribed from report; in process of loading and checking as of 1/30/00.

<u>DOW AGROSCIENCES (45)</u>: "A monitoring study to characterize chlorpyrifos concentration patterns and ecological risk in an agriculturally dominated tributary of the San Joaquin River" by N.N. Poletika and C.K. Robb, Dow AgroSciences LLC Study ENV96055, November 18, 1998. 3173 pesticide analysis records; no bioassays; no water quality data reported. Daily composite samples were taken

from three sites on Orestimba Creek, Stanislaus County, from 5/96 through 4/97 and analyzed for chlorpyrifos, diazinon, and methidathion. Weekly grab samples also collected from the Orestimba Creek site near Crows Landing. Chlorpyrifos was detected in 786 of 1143 samples, diazinon in 877 of 1063, and methidathion in 58 of 967 samples. QA/QC information given in report. Dataset transmitted electronically and checked against report. Originals at Dow AgroSciences.

UNITED STATES GEOLOGICAL SURVEY (46): "Occurrence and distribution of dissolved pesticides in the San Joaquin River Basin, California", by S.Y. Panshin, N.M. Dubrovsky, J.M. Gronbert, and J.L. Domagalski, 1998. USGS National Water-Quality Assessment Program, water-resources investigations report 98-4032. Water samples were collected throughout 1993 from sites on the San Joaquin River and three of its tributaries: Orestimba Creek, Salt Slough, and the Merced River. Of 83 pesticides analyzed for, 49 compounds were detected. Six compounds were detected in more than 50% of the samples: dacthal, EPTC, metolachlor, simazine, chlorpyrifos, and diazinon. QA/QC information given in report. Data downloaded from internet and in process of being loaded and checked as of 1/30/00.

UNITED STATES GEOLOGICAL SURVEY (47): "Pesticides in storm runoff from agricultural and urban areas in the Tuolumne River basin in the vicinity of Modesto, California" by C.R. Kratzer, 1998. USGS National Water-Quality Assessment Program, water-resources investigations report 98-4017. 5,142 pesticide analysis records; no bioassays; no water quality data. Storm runoff samples taken from an agricultural site and urban storm drains in Modesto were analyzed for 46 pesticides; 15 were detected overall. QA/QC information not given in report, however, NAWQA methods are well documented and can be accessed through USGS. Data downloaded from internet and checked against report.

CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD (48): "Sources and concentrations of diazinon in the Sacramento watershed during the 1994 orchard spray season" by R. Holmes, C. Foe and V. De Vlaming, draft June 1998. 1,422 pesticide and ELISA analysis records; no bioassays; no water quality data. Water samples were collected before and after rainstorms from 21 sites on the Sacramento and Feather rivers and their tributaries in January through March 1994. Samples were analyzed for diazinon and 29 other pesticides, 25 were detected at least once. QA/QC information, including split sample comparisons and recoveries, is given in report. Method validation is referenced. Detections reported below the LOQ were entered as zero in the database. Data transcribed from report.

DEPARTMENT OF PESTICIDE REGULATION (57): Nordmark, Craig. 1999. Preliminary results of acute and chronic toxicity testing of surface water monitored in the Sacramento River watershed, winter 1998-99. Memorandum to Don Weaver, Environmental Monitoring and Pest Management, Department of Pesticide Regulation, Sacramento, California. May 26, 1999. 1,460 pesticide analysis records, 57 biotoxicity test result measurements. Water samples were taken from the Sacramento River at Alamar (Sacramento County), two sites in the Sutter Bypass, and the Wadsworth Canal from December 1998 through March 1999. The samples were analyzed for 19 pesticide active ingredients. Diuron was detected at all 3 sites. Diazinon and diuron were detected in Sutter Bypass. Bromacil, diazinon, diuron, hexazinone, methidathion, and simazine were detected in Wadsworth Canal. Significant biotoxicity was not seen in acute or chronic samples. Ratio of pesticide analysis samples to acute and chronic biotoxicity testing samples = 1:1. "Quality control for the chemistry portion of this study was in accordance with Standard Operating Procedure (QCQC001.00). A continuing QC program, equipment rinse blanks, blind spikes, spike recovery, method development, and more detailed QC data will be included in the final report." Method validation referenced to the USEPA. Data entered from original COCs.

DEPARTMENT OF PESTICIDE REGULATION (58): Ganapathy, Carissa. 1999. Preliminary results of acute and chronic toxicity testing of surface water monitored in the San Joaquin River watershed, winter 1998-99. Memorandum to Don Weaver, Environmental Monitoring and Pest Management, Department of Pesticide Regulation, Sacramento, California. July 20, 1999. 1,026 pesticide analysis records, 91 biotoxicity test result measurements. Water samples were taken from the San Joaquin River at Vernalis and Orestimba Creek, a tributary to the San Joaquin, from December 1998 through March 1999 and analyzed for a total of 19 pesticide active ingredients. Bromacil, cyanazine, diuron, and simazine were detected at both sites. In addition, diazinon was detected in the San Joaquin River. Bioassay data in process of loading 1/30/00. "Quality control for the chemistry portion of this study was in accordance with Standard Operating Procedure (QCQC001.00). A continuing QC program, equipment rinse blanks, blind spikes, spike recovery, method development, and more detailed QC data will be included in the final report." Method validation referenced to the USEPA. Data entered from original COCs.

DEPARTMENT OF PESTICIDE REGULATION (62): Jones, DeeAn. 1999. Protocol for monitoring acute and chronic toxicity in the San Joaquin River watershed, winter 1999-2000. Document Review and Approval, Environmental Monitoring and Pest Management, Department of Pesticide Regulation, Sacramento, California. November 30, 1999. 1,026 pesticide analysis records. Water samples were taken from the San Joaquin River at Vernalis and Orestimba Creek, a tributary to the San Joaquin, from December 1999 through March 2000 and analyzed for a total of 19 pesticide active ingredients. Bromacil, cyanazine, diuron, and simazine were detected at both sites. In addition, diazinon was detected in the San Joaquin River. Bioassay data still being processed by laboratory. "Quality control for the chemistry portion of this study was in accordance with Standard Operating Procedure (QCQC001.00). A continuing QC program, equipment rinse blanks, blind spikes, spike recovery, method development, and more detailed QC data will be included in the final report." Method validation referenced to the USEPA. Data entered from original COCs.

DEPARTMENT OF PESTICIDE REGULATION (63): Nordmark, Craig. 1999. Protocol for monitoring acute and chronic toxicity in the Sacramento River watershed, winter 1999-2000. Environmental Monitoring and Pest Management, Department of Pesticide Regulation, Sacramento, California. November 1, 1999. 1,460 pesticide analysis records. Water samples were taken from the Sacramento River at Alamar (Sacramento County), two sites in the Sutter Bypass, and the Wadsworth Canal from December 1999 through March 2000. The samples were analyzed for 19 pesticide active ingredients. Diuron was detected at all 3 sites. Diazinon and diuron were detected in Sutter Bypass. Bromacil, diazinon, diuron, hexazinone, methidathion, and simazine were detected in Wadsworth Canal. Bioassay data still being processed by laboratory. "Quality control for the chemistry portion of this study was in accordance with Standard Operating Procedure (QCQC001.00). A continuing QC program, equipment rinse blanks, blind spikes, spike recovery, method development, and more detailed QC data will be included in the final report." Method validation referenced to the USEPA. Data entered from original COCs.

DEPARTMENT OF PESTICIDE REGULATION (70): Bacey, J. 2000. Protocol for monitoring acute and chronic toxicity in the San Joaquin River watershed, winter 2000-2001. Document Review and Approval, Environmental Monitoring and Pest Management, Department of Pesticide Regulation, Sacramento, California. November, 2000. Water samples were taken from the San Joaquin River at Vernalis and Orestimba Creek, a tributary to the San Joaquin, from December 2000 through March 2001 and analyzed for a total of 19 pesticide active ingredients. "Quality control for the chemistry portion of this study was in accordance with Standard Operating Procedure (QAQC001.00). A continuing QC program, equipment rinse blanks, blind spikes, spike recovery, method development, and more detailed QC data will be included in the final report." Method validation referenced to the USEPA. Data entered from original COCs.

DEPARTMENT OF PESTICIDE REGULATION (71): Jones, D. 2000. Protocol for monitoring acute and chronic toxicity in the Sacramento River watershed, winter 2000-2001. Environmental Monitoring and Pest Management, Department of Pesticide Regulation, Sacramento, California. November 2000. Water samples were taken from the Sacramento River at Alamar (Sacramento County), two sites in the Sutter Bypass, and the Wadsworth Canal from December 2000 through March 2001. The samples were analyzed for 19 pesticide active ingredients. "Quality control for the chemistry portion of this study was in accordance with Standard Operating Procedure (QCQC001.00). A continuing QC program, equipment rinse blanks, blind spikes, spike recovery, method development, and more detailed QC data will be included in the final report." Method validation referenced to the USEPA. Data entered from original COCs.

LOQ = limit of quantitation
GC/FPD = gas chromatography/flame photometric detector
HPLC/PCDFD = high pressure liquid chromatography/post column derivitization with fluorescence detector
GC/ECD = gas chromatography/electron capture detector
GC/NPD = gas chromatography/nitrogen phosphorus detector
GC/MSD = gas chromatography/mass selective detector

Appendix 2. Highest 100 diazinon concentrations reported in rivers.

Appendix 2. 100 highest diazinon concentrations measured in rivers.

rank	diazinon ug/L	LOQ ug/L	site code	date	study code	site description
1	2.5	0.002	2407	02/11/93	46	Merced River at River Road Bridge near Newman
2	1.9967	0.002	5007	01/26/94	39	Tuolumne River at Modesto
3	1.69	0.05	5029	02/09/93	10	San Joaquin River at Hills Ferry
4	1.5	0.1	1303	09/27/93	13	Alamo River at Shank Road (Magnolia Drain Area
5	1.29	0.05	5015	01/14/93	10	San Joaquin River at Laird Park
6	1.22	0.05	5015	02/11/93	10	San Joaquin River at Laird Park
7	1.18	0.05	5023	02/10/93	10	San Joaquin River at West Main
8	1.1	0.1	1306	10/04/93	13	Alamo River at Harris Street Bridge
9	0.86	0.1	1307	10/04/93	13	Alamo River at Worthington Road
10	0.78	0.1	1304	09/27/93	13	Alamo River downstream of Rose Drain
11	0.771	0.023	5107	01/26/94	48	Feather River near Nicolaus at Hwy 99 Bridge
12	0.77	0.05	5015	02/10/93	10	San Joaquin River at Laird Park
13	0.73	0.1	1301	09/27/93	13	Alamo River at Outlet
14	0.72	0.1	1302	09/27/93	13	Alamo River at Albright Road (Nectarine Drain Area
15	0.714	0.031	3917	02/09/93	9	San Joaquin River near Vernalis
16	0.61	0.002	2407	01/25/94	39	Merced River at River Road Bridge near Newman
17	0.591	0.031	3917	02/12/93	9	San Joaquin River near Vernalis
18	0.582	0.031	3917	02/11/93	9	San Joaquin River near Vernalis
19	0.57	0.1	1301	10/18/93	13	Alamo River at Outlet
20	0.53	0.1	1302	10/04/93	13	Alamo River at Albright Road (Nectarine Drain Area
21	0.527	0.038	3917	02/12/92	9	San Joaquin River near Vernalis
22	0.52	0.002	5016	02/09/94	39	Tuolumne River at Shiloh
23	0.5133	0.05	3907	02/17/92	43	San Joaquin River at Bowman Rd
24	0.5	0.002	2407	02/09/93	46	Merced River at River Road Bridge near Newman
25	0.46	0.1	1301	10/04/93	13	Alamo River at Outlet
26	0.452	0.031	3917	02/08/93	9	San Joaquin River near Vernalis
27	0.42	0.1	1302	10/18/93	13	Alamo River at Albright Road (Nectarine Drain Area
28	0.42	0.1	1308	10/04/93	13	Alamo River at Holtville WTP
29	0.41	0.1	1305	09/27/93	13	Alamo River downstream of Holtville Main Drain
30	0.4	0.05	2406	02/09/93	10	Merced River at Hatfield State Park
31	0.4	0.1	1305	11/29/93	13	Alamo River downstream of Holtville Main Drain
32	0.4	0.05	3907	02/24/92	43	San Joaquin River at Bowman Rd
33	0.395	0.031	3917	01/15/93	9	San Joaquin River near Vernalis
34	0.3745	0.023	5107	01/27/94	48	Feather River near Nicolaus at Hwy 99 Bridge
35	0.37	0.05	5002	02/10/93	10	San Joaquin River at Maze Blvd.
36	0.3697	0.002	5007	02/08/94	39	Tuolumne River at Modesto
37	0.365	0.002	2407	01/26/94	39	Merced River at River Road Bridge near Newman
38	0.36	0.05	3917	02/10/93	10	San Joaquin River near Vernalis
39	0.3567	0.05	3908	02/17/92	43	Old River off Cohen Road
40	0.35	0.05	5015	02/13/92	10	San Joaquin River at Laird Park
41	0.35	0.1	1306	09/27/93	13	Alamo River at Harris Street Bridge
42	0.34	0.1	1309	10/04/93	13	Alamo River at Holtville
43	0.335	0.031	3917	02/13/93	9	San Joaquin River near Vernalis
44	0.32	0.05	2409	08/25/92	10	San Joaquin River at Fremont Ford
45	0.319	0.031	3917	01/10/93	9	San Joaquin River near Vernalis
46	0.31	0.05	5015	01/11/93	10	San Joaquin River at Laird Park
47	0.307	0.038	3413	02/12/93	9	Sacramento River at I Street Bridge
48	0.3	0.1	1301	11/29/93	13	Alamo River at Outlet
49	0.3	0.1	1303	11/29/93	13	Alamo River at Shank Road (Magnolia Drain Area
50	0.3	0.1	1304	11/29/93	13	Alamo River downstream of Rose Drain
51	0.3	0.1	1306	11/01/93	13	Alamo River at Harris Street Bridge

rank	diazinon ug/L	LOQ ug/L	site code	date	study code	site description
52	0.296	0.031	3917	02/14/93	9	San Joaquin River near Vernalis
53	0.295	0.031	3917	01/16/93	9	San Joaquin River near Vernalis
54	0.293	0.031	3917	02/15/93	9	San Joaquin River near Vernalis
55	0.293	0.038	5107	01/25/94	48	Feather River near Nicolaus at Hwy 99 Bridge
56	0.29	0.008	5201	02/18/94	48	Sacramento River at Vina at Woodson Bridge
57	0.288	0.031	3917	01/25/94	9	San Joaquin River near Vernalis
58	0.283	0.031	3917	01/14/93	9	San Joaquin River near Vernalis
59	0.28	0.031	3917	02/10/93	9	San Joaquin River near Vernalis
60	0.28	0.05	704	02/10/92	43	Marsh Creek at Cypress Rd bridge (trib: westrn Delta)
61	0.272	0.038	3413	02/11/93	9	Sacramento River at I Street Bridge
62	0.26	0.05	2411	02/08/93	10	San Joaquin River near Stevinson
63	0.253	0.038	3413	02/10/94	9	Sacramento River at I Street Bridge
64	0.252	0.031	3917	01/27/94	9	San Joaquin River near Vernalis
65	0.25	0.031	3917	08/19/93	9	San Joaquin River near Vernalis
66	0.25	0.05	5015	02/15/93	10	San Joaquin River at Laird Park
67	0.245	0.031	3917	02/22/93	9	San Joaquin River near Vernalis
68	0.243	0.031	3917	02/10/94	9	San Joaquin River near Vernalis
69	0.236	0.038	3413	01/27/94	9	Sacramento River at I Street Bridge
70	0.23	0.05	5015	02/04/93	10	San Joaquin River at Laird Park
71	0.23	0.05	3919	01/27/92	43	Mokelumne River at New Hope Rd Bridge (in Delta)
72	0.23	0.002	5007	01/25/94	47	Tuolumne River at Modesto
73	0.228	0.031	3917	02/19/93	9	San Joaquin River near Vernalis
74	0.22	0.05	5016	02/19/92	10	Tuolumne River at Shiloh
75	0.22	0.008	604	02/08/94	48	SacRiver at Colusa, 60 ft. dwnstrm from hwy bridge
76	0.211	0.031	3917	01/19/93	9	San Joaquin River near Vernalis
77	0.21	0.05	5015	08/05/92	10	San Joaquin River at Laird Park
78	0.21	0.1	1320	10/04/93	13	Alamo River downstream of Verde Drain
79	0.2033	0.002	5007	02/09/94	39	Tuolumne River at Modesto
80	0.203	0.038	5801	01/24/94	48	Bear River at Berry Road
81	0.2	0.1	1307	11/01/93	13	Alamo River at Worthington Road
82	0.2	0.1	1308	11/01/93	13	Alamo River at Holtville WTP
83	0.2	0.05	2701	06/26/95	14	Salinas Lagoon
84	0.195	0.031	3917	01/20/93	9	San Joaquin River near Vernalis
85	0.193	0.038	3413	02/21/93	9	Sacramento River at I Street Bridge
86	0.192	0.038	3917	02/16/92	9	San Joaquin River near Vernalis
87	0.191	0.038	3413	02/22/93	9	Sacramento River at I Street Bridge
88	0.191	0.038	3917	02/14/92	9	San Joaquin River near Vernalis
89	0.19	0.1	1306	10/18/93	13	Alamo River at Harris Street Bridge
90	0.19	0.01	5029	03/16/92	35	San Joaquin River at Hills Ferry
91	0.19	0.002	2407	02/25/93	46	Merced River at River Road Bridge near Newman
92	0.189	0.031	3917	01/13/93	9	San Joaquin River near Vernalis
93	0.183	0.031	3917	01/23/93	9	San Joaquin River near Vernalis
94	0.18	0.038	3413	02/11/94	9	Sacramento River at I Street Bridge
95	0.18	0.05	5016	02/10/93	10	Tuolumne River at Shiloh
96	0.18	0.05	5023	08/05/92	10	San Joaquin River at West Main
97	0.18	0.1	1304	10/18/93	13	Alamo River downstream of Rose Drain
98	0.18	0.1	1305	10/18/93	13	Alamo River downstream of Holtville Main Drain
99	0.18	0.1	1320	02/14/94	13	Alamo River downstream of Verde Drain
100	0.177	0.031	3917	02/26/93	9	San Joaquin River near Vernalis

Appendix 3. Highest 100 diazinon concentrations reported in tributaries.

Appendix 3. 100 highest diazinon concentrations measured in tributaries.

rank	diazinon ug/L	LOQ ug/L	site code	date	study code	site description
1	36.82	0.05	2408	02/09/93	10	Newman Wasteway (trib. to SJR)
2	29.371	0.001	5027	03/27/97	45	Orestimba Creek above Crow Creek Drain
3	16.813	0.001	5027	03/28/97	45	Orestimba Creek above Crow Creek Drain
4	16.291	0.001	5028	04/30/97	45	Orestimba Creek at River Road (trib. to SJR)
5	9.72	0.001	5026	07/27/96	45	Orestimba Creek at State Hwy. 33 bridge
6	7.799	0.001	5027	03/29/97	45	Orestimba Creek above Crow Creek Drain
7	6.84	0.05	5109	02/17/92	43	Gilsizer Slough at G. Washington Rd (trib to Butte Slough)
8	5.609	0.001	5027	03/30/97	45	Orestimba Creek above Crow Creek Drain
9	4.8	0.008	5113	02/08/94	48	Wadsworth Canal at Franklin Rd
10	4.5	0.008	5113	02/09/94	48	Wadsworth Canal at Franklin Rd
11	4.03	0.001	5028	04/30/97	45	Orestimba Creek at River Road (trib. to SJR)
12	3.97	0.05	5109	02/03/92	43	Gilsizer Slough at G. Washington Rd (trib to Butte Slough)
13	3.857	0.001	5026	03/28/97	45	Orestimba Creek at State Hwy. 33 bridge
14	3.8	0.002	5028	02/08/93	46	Orestimba Creek at River Road (trib. to SJR)
15	3.654	0.001	5027	04/05/97	45	Orestimba Creek above Crow Creek Drain
16	3.39	0.05	5109	02/10/92	43	Gilsizer Slough at G. Washington Rd (trib to Butte Slough)
17	3.2	0.002	5028	02/08/93	46	Orestimba Creek at River Road (trib. to SJR)
18	2.927	0.001	5026	03/27/97	45	Orestimba Creek at State Hwy. 33 bridge
19	2.9	0.008	401	02/08/94	48	Main Drainage Canal, Colusa Hwy (trib to Cherokee Canal)
20	2.8	0.008	5110	02/08/94	48	Sacramento Outfall at DWR PP on Sacramento Road
21	2.79	0.05	3909	02/10/92	43	Lone Tree Creek at Austin Rd trib to French Camp Slough
22	2.74	0.04	5113	01/31/00	63	Wadsworth Canal at Franklin Rd
23	2.598	0.001	5027	04/04/97	45	Orestimba Creek above Crow Creek Drain
24	2.54	0.05	2404	02/08/93	10	Highline Spillway (trib. to SJR)
25	2.436	0.001	5028	07/28/96	45	Orestimba Creek at River Road (trib. to SJR)
26	2.414	0.001	5028	03/28/97	45	Orestimba Creek at River Road (trib. to SJR)
27	2.14	0.05	2408	02/17/92	10	Newman Wasteway (trib. to SJR)
28	2	0.008	5113	02/10/94	48	Wadsworth Canal at Franklin Rd
29	1.738	0.001	5027	04/06/97	45	Orestimba Creek above Crow Creek Drain
30	1.738	0.04	5113	02/14/00	63	Wadsworth Canal at Franklin Rd
31	1.7	0.002	2404	02/08/94	39	Highline Spillway (trib. to SJR)
32	1.7	0.002	5028	02/08/93	46	Orestimba Creek at River Road (trib. to SJR)
33	1.69	0.05	5024	02/09/93	10	Turlock Irrig. Dist. Drain #5
34	1.61	0.04	5113	02/08/99	57	Wadsworth Canal at Franklin Rd
35	1.5	0.008	5103	02/10/94	48	Sacramento Slough near Karnak
36	1.421	0.023	401	01/24/94	48	Main Drainage Canal, Colusa Hwy (trib to Cherokee Canal)
37	1.41	0.05	601	02/17/92	43	Clarks Ditch, trib. to Colusa Basin Drain
38	1.38	0.002	3415	05/23/97	41	Arcade Creek at Norwood
39	1.374	0.001	5027	07/28/96	45	Orestimba Creek above Crow Creek Drain
40	1.373	0.001	5028	03/27/97	45	Orestimba Creek at River Road (trib. to SJR)
41	1.32	0.05	2403	02/09/93	10	Stevinson Spillway (trib. to SJR)
42	1.32	0.04	5113	01/08/01	99	Wadsworth Canal at Franklin Rd
43	1.3	0.01	5018	02/03/92	35	Del Puerto Creek (trib. to SJR)
44	1.3	0.01	5019	02/10/92	35	Turlock Irrig. Dist. Drain #3 at Jennings Rd Bridge
45	1.273	0.001	5026	03/29/97	45	Orestimba Creek at State Hwy. 33 bridge
46	1.27	0.04	5113	02/17/99	57	Wadsworth Canal at Franklin Rd
47	1.26	0.023	5103	01/27/94	48	Sacramento Slough near Karnak
48	1.11	0.05	3903	02/10/92	43	French Camp Slough at Manthey Bridge
49	1.11	0.04	5113	02/01/99	57	Wadsworth Canal at Franklin Rd
50	1.1	0.008	401	02/20/94	48	Main Drainage Canal, Colusa Hwy (trib to Cherokee Canal)
51	1.085	0.001	5027	04/07/97	45	Orestimba Creek above Crow Creek Drain

rank	diazinon ug/L	LOQ ug/L	site code	date	study code	site description
52	1.04	0.05	3909	01/27/92	43	Lone Tree Creek at Austin Rd trib to French Camp Slough
53	1.03	0.05	2405	01/15/93	10	Livingston Spillway (trib. to SJR)
54	1.02	0.04	5113	02/10/99	57	Wadsworth Canal at Franklin Rd
55	1.01	0.001	5028	03/02/97	45	Orestimba Creek at River Road (trib. to SJR)
56	1	0.008	401	02/09/94	48	Main Drainage Canal at Colusa Hwy (trib: Cherokee Canal)
57	1	0.008	5110	02/09/94	48	Sacramento Outfall at DWR PP on Sacramento Road
58	1	0.008	5115	02/08/94	48	Butte Slough at Lower Pass Road
59	0.98	0.05	3909	02/03/92	43	Lone Tree Creek at Austin Rd trib to French Camp Slough
60	0.98	0.001	5026	07/22/96	45	Orestimba Creek at State Hwy. 33 bridge
61	0.951	0.001	5026	03/01/97	45	Orestimba Creek at State Hwy. 33 bridge
62	0.9	0.01	5014	05/25/92	35	Ingram/Hospital Creek (trib. to SJR)
63	0.89	0.002	2405	02/08/94	39	Livingston Spillway (trib. to SJR)
64	0.85	0.008	5103	02/11/94	48	Sacramento Slough near Karnak
65	0.841	0.002	3415	11/14/97	41	Arcade Creek at Norwood
66	0.83	0.05	5109	01/27/92	43	Gilsizer Slough at G. Washington Rd (trib to Butte Slough)
67	0.803	0.001	5026	04/06/97	45	Orestimba Creek at State Hwy. 33 bridge
68	0.78	0.05	2405	02/08/93	10	Livingston Spillway (trib. to SJR)
69	0.76	0.008	5111	02/09/94	48	Obanion Outfall at DWR PP on Obanion Road
70	0.728	0.002	3415	04/23/97	41	Arcade Creek at Norwood
71	0.7	0.002	5028	02/08/93	46	Orestimba Creek at River Road (trib. to SJR)
72	0.694	0.001	5028	03/29/97	45	Orestimba Creek at River Road (trib. to SJR)
73	0.66	0.05	601	02/24/92	43	Clarks Ditch, trib. to Colusa Basin Drain
74	0.6545	0.023	5113	01/24/94	48	Wadsworth Canal at Franklin Rd
75	0.651	0.001	5026	04/07/97	45	Orestimba Creek at State Hwy. 33 bridge
76	0.65	0.01	5018	02/10/92	35	Del Puerto Creek (trib. to SJR)
77	0.64	0.008	5802	02/08/94	48	Jack Slough at Marysville
78	0.615	0.002	5008	02/14/95	47	Dry Creek at Gallo Rd near Modesto
79	0.6	0.05	5028	02/18/92	10	Orestimba Creek at River Road (trib. to SJR)
80	0.6	0.01	5025	05/11/92	35	Spanish Grant Drain (trib. to SJR)
81	0.591	0.001	5027	03/31/97	45	Orestimba Creek above Crow Creek Drain
82	0.59	0.008	5103	01/29/94	48	Sacramento Slough near Karnak
83	0.5785	0.023	5802	01/24/94	48	Jack Slough at Marysville
84	0.571	0.023	5103	01/28/94	48	Sacramento Slough near Karnak
85	0.568	0.04	5113	02/23/00	63	Wadsworth Canal at Franklin Rd
86	0.553	0.001	5028	07/29/96	45	Orestimba Creek at River Road (trib. to SJR)
87	0.55	0.008	401	02/10/94	48	Main Drainage Canal, Colusa Hwy (trib to Cherokee Canal)
88	0.55	0.008	5113	02/21/94	48	Wadsworth Canal at Franklin Rd
89	0.545	0.002	3415	01/13/97	41	Arcade Creek at Norwood
90	0.543	0.001	5027	04/03/97	45	Orestimba Creek above Crow Creek Drain
91	0.541	0.04	5113	02/16/00	63	Wadsworth Canal at Franklin Rd
92	0.54	0.001	5026	04/05/97	45	Orestimba Creek at State Hwy. 33 bridge
93	0.54	0.002	5028	02/08/93	46	Orestimba Creek at River Road (trib. to SJR)
94	0.536	0.04	5113	02/12/01	99	Wadsworth Canal at Franklin Rd
95	0.53	0.008	5111	02/10/94	48	Obanion Outfall at DWR PP on Obanion Road
96	0.52	0.05	5028	04/15/92	10	Orestimba Creek at River Road (trib. to SJR)
97	0.51	0.05	5109	02/24/92	43	Gilsizer Slough at G. Washington Rd (trib to Butte Slough)
98	0.506	0.002	3415	04/10/97	41	Arcade Creek at Norwood
99	0.504	0.04	5113	02/02/00	63	Wadsworth Canal at Franklin Rd
100	0.5	0.008	5110	02/10/94	48	Sacramento Outfall at DWR PP on Sacramento Road

Appendix 4. Highest 100 chlorpyrifos concentrations reported in rivers.

Appendix 4. 100 highest chlorpyrifos concentrations measured in rivers.

rank	chlorpyrifc ug/L	LOQ ug/L	site code	date	study code	site description
1	0.35	0.1	1306	09/27/93	13	Alamo River at Harris Street Bridge
2	0.34	0.1	1307	10/04/93	13	Alamo River at Worthington Road
3	0.34	0.05	5015	08/19/92	10	San Joaquin River at Laird Park
4	0.29	0.1	1306	10/04/93	13	Alamo River at Harris Street Bridge
5	0.26	0.004	2407	02/11/93	46	Merced River at River Road Bridge near Newman
6	0.24	0.1	1301	10/04/93	13	Alamo River at Outlet
7	0.21	0.1	1301	10/18/93	13	Alamo River at Outlet
8	0.2	0.1	1302	10/04/93	13	Alamo River at Albright Road (Nectarine Drain Area
9	0.2	0.1	1305	11/29/93	13	Alamo River downstream of Holtville Main Drain
10	0.18	0.1	1301	09/27/93	13	Alamo River at Outlet
11	0.17	0.1	1302	09/27/93	13	Alamo River at Albright Road (Nectarine Drain Area
12	0.15	0.1	1302	10/18/93	13	Alamo River at Albright Road (Nectarine Drain Area
13	0.13	0.1	1304	09/27/93	13	Alamo River downstream of Rose Drain
14	0.13	0.1	1308	10/04/93	13	Alamo River at Holtville WTP
15	0.12	0.1	1306	10/18/93	13	Alamo River at Harris Street Bridge
16	0.12	0.004	2407	03/12/93	46	Merced River at River Road Bridge near Newman
17	0.12	0.05	2703	01/10/95	14	Salinas River at Gonzales River Rd. bridge
18	0.1	0.1	1306	11/01/93	13	Alamo River at Harris Street Bridge
19	0.1	0.1	1307	11/01/93	13	Alamo River at Worthington Road
20	0.085	0.01	5023	04/26/91	35	San Joaquin River at West Main
21	0.083	0.004	2407	02/09/93	46	Merced River at River Road Bridge near Newman
22	0.08	0.05	5023	04/25/91	10	San Joaquin River at West Main
23	0.08	0.05	5023	02/10/93	10	San Joaquin River at West Main
24	0.07	0.05	2401	02/07/93	10	Merced River at Oakdale Road
25	0.07	0.05	5015	02/11/93	10	San Joaquin River at Laird Park
26	0.065	0.01	2406	04/13/92	35	Merced River at Hatfield State Park
27	0.06	0.05	2406	02/18/92	10	Merced River at Hatfield State Park
28	0.06	0.05	2406	02/09/93	10	Merced River at Hatfield State Park
29	0.06	0.01	5015	04/26/91	35	San Joaquin River at Laird Park
30	0.06	0.05	5015	02/10/93	10	San Joaquin River at Laird Park
31	0.05	0.05	5015	03/18/91	10	San Joaquin River at Laird Park
32	0.05	0.05	5015	04/25/91	10	San Joaquin River at Laird Park
33	0.048	0.004	2407	02/08/93	46	Merced River at River Road Bridge near Newman
34	0.047	0.004	2407	02/08/93	46	Merced River at River Road Bridge near Newman
35	0.045	0.004	2407	02/08/93	46	Merced River at River Road Bridge near Newman
36	0.043	0.035	3917	02/12/93	09	San Joaquin River near Vernalis
37	0.042	0.004	2407	01/29/93	46	Merced River at River Road Bridge near Newman
38	0.038	0.004	2407	02/01/93	46	Merced River at River Road Bridge near Newman
39	0.036	0.004	2407	02/04/93	46	Merced River at River Road Bridge near Newman
40	0.035	0.004	2407	01/26/93	46	Merced River at River Road Bridge near Newman
41	0.035	0.004	2407	02/25/93	46	Merced River at River Road Bridge near Newman
42	0.034	0.004	2407	03/09/93	46	Merced River at River Road Bridge near Newman
43	0.033	0.004	2407	02/23/93	46	Merced River at River Road Bridge near Newman
44	0.032	0.004	5007	01/25/94	47	Tuolumne River at Modesto
45	0.031	0.004	2407	01/22/93	46	Merced River at River Road Bridge near Newman
46	0.03	0.004	2407	03/15/93	46	Merced River at River Road Bridge near Newman
47	0.0283	0.004	5007	01/26/94	47	Tuolumne River at Modesto
48	0.027	0.004	2407	04/01/93	46	Merced River at River Road Bridge near Newman
49	0.026	0.004	2407	03/18/93	46	Merced River at River Road Bridge near Newman
50	0.026	0.004	2407	03/22/93	46	Merced River at River Road Bridge near Newman
51	0.026	0.004	3917	03/21/95	47	San Joaquin River near Vernalis

rank	chlorpyrifc ug/L	LOQ ug/L	site code	date	study code	site description
52	0.025	0.01	2406	02/17/92	35	Merced River at Hatfield State Park
53	0.024	0.004	2407	03/29/93	46	Merced River at River Road Bridge near Newman
54	0.02	0.01	5015	03/09/92	35	San Joaquin River at Laird Park
55	0.019	0.004	2407	03/26/93	46	Merced River at River Road Bridge near Newman
56	0.018	0.004	2407	03/02/93	46	Merced River at River Road Bridge near Newman
57	0.018	0.004	3917	03/12/95	47	San Joaquin River near Vernalis
58	0.016	0.004	2407	07/15/93	46	Merced River at River Road Bridge near Newman
59	0.015	0.01	3917	03/09/92	35	San Joaquin River near Vernalis
60	0.015	0.01	5015	04/20/92	35	San Joaquin River at Laird Park
61	0.015	0.01	5016	02/17/92	35	Tuolumne River at Shiloh
62	0.013	0.004	2407	04/06/93	46	Merced River at River Road Bridge near Newman
63	0.013	0.004	5007	01/18/94	47	Tuolumne River at Modesto
64	0.012	0.004	5007	01/11/94	47	Tuolumne River at Modesto
65	0.0103	0.004	5007	02/08/94	47	Tuolumne River at Modesto
66	0.01	0.004	2407	04/27/93	46	Merced River at River Road Bridge near Newman
67	0.01	0.05	3916	04/13/92	43	Bishop Cut at Eight Mile Rd (in Delta)
68	0.01	0.01	3917	02/17/92	35	San Joaquin River near Vernalis
69	0.01	0.01	5002	04/26/91	35	San Joaquin River at Maze Blvd.
70	0.01	0.01	5015	05/28/91	35	San Joaquin River at Laird Park
71	0.01	0.01	5015	04/13/92	35	San Joaquin River at Laird Park
72	0.01	0.01	5015	04/27/92	35	San Joaquin River at Laird Park
73	0.01	0.01	5015	05/04/92	35	San Joaquin River at Laird Park
74	0.01	0.01	5015	05/11/92	35	San Joaquin River at Laird Park
75	0.01	0.01	5016	01/20/92	35	Tuolumne River at Shiloh
76	0.01	0.01	5029	05/11/92	35	San Joaquin River at Hills Ferry
77	0.009	0.004	3917	02/02/95	47	San Joaquin River near Vernalis
78	0.0085	0.004	5017	03/10/95	47	Tuolumne River at Carpenter Rd Bridge
79	0.0077	0.004	5007	02/09/94	47	Tuolumne River at Modesto
80	0.007	0.004	2407	05/04/93	46	Merced River at River Road Bridge near Newman
81	0.007	0.004	2407	05/21/93	46	Merced River at River Road Bridge near Newman
82	0.007	0.004	2407	06/01/93	46	Merced River at River Road Bridge near Newman
83	0.007	0.004	2407	06/14/93	46	Merced River at River Road Bridge near Newman
84	0.006	0.004	2407	06/29/93	46	Merced River at River Road Bridge near Newman
85	0.005	0.01	2406	04/26/91	35	Merced River at Hatfield State Park
86	0.005	0.01	2406	01/20/92	35	Merced River at Hatfield State Park
87	0.005	0.01	2406	03/09/92	35	Merced River at Hatfield State Park
88	0.005	0.01	2406	04/27/92	35	Merced River at Hatfield State Park
89	0.005	0.01	2406	05/04/92	35	Merced River at Hatfield State Park
90	0.005	0.01	2409	04/26/91	35	San Joaquin River at Fremont Ford
91	0.005	0.01	3917	05/15/91	35	San Joaquin River near Vernalis
92	0.005	0.01	3917	01/20/92	35	San Joaquin River near Vernalis
93	0.005	0.01	3917	04/27/92	35	San Joaquin River near Vernalis
94	0.005	0.01	3917	05/04/92	35	San Joaquin River near Vernalis
95	0.005	0.01	3917	05/11/92	35	San Joaquin River near Vernalis
96	0.005	0.01	3918	04/26/91	35	Stanislaus River at Caswell State Park
97	0.005	0.01	3918	06/12/91	35	Stanislaus River at Caswell State Park
98	0.005	0.01	5015	05/15/91	35	San Joaquin River at Laird Park
99	0.005	0.01	5015	01/20/92	35	San Joaquin River at Laird Park
100	0.005	0.01	5015	02/03/92	35	San Joaquin River at Laird Park

Appendix 5. Highest 100 chlorpyrifos concentrations reported in tributaries.

Appendix 5. 100 highest chlorpyrifos concentrations measured in tributaries.

rank	chlorpyrifo ug/L	LOQ ug/L	site code	date	study code	site description
1	2.282	0.001	5027	03/28/97	45	Orestimba Creek above Crow Creek Drain
2	1.462	0.001	5027	03/27/97	45	Orestimba Creek above Crow Creek Drain
3	1.455	0.001	5028	04/23/97	45	Orestimba Creek at River Road (trib. to SJR)
4	1.255	0.001	5027	03/29/97	45	Orestimba Creek above Crow Creek Drain
5	1.167	0.001	5028	08/21/96	45	Orestimba Creek at River Road (trib. to SJR)
6	1.037	0.001	5028	03/26/97	45	Orestimba Creek at River Road (trib. to SJR)
7	0.986	0.001	5028	05/29/96	45	Orestimba Creek at River Road (trib. to SJR)
8	0.937	0.001	5027	07/27/96	45	Orestimba Creek above Crow Creek Drain
9	0.931	0.001	5027	05/21/96	45	Orestimba Creek above Crow Creek Drain
10	0.897	0.001	5026	03/22/97	45	Orestimba Creek at State Hwy. 33 bridge
11	0.825	0.001	5026	03/23/97	45	Orestimba Creek at State Hwy. 33 bridge
12	0.8	0.01	5019	01/20/92	35	Turlock Irrig. Dist. Drain #3 at Jennings Rd Bridge
13	0.742	0.001	5027	03/26/97	45	Orestimba Creek above Crow Creek Drain
14	0.72	0.001	5028	08/22/96	45	Orestimba Creek at River Road (trib. to SJR)
15	0.691	0.001	5028	05/29/96	45	Orestimba Creek at River Road (trib. to SJR)
16	0.661	0.001	5026	03/26/97	45	Orestimba Creek at State Hwy. 33 bridge
17	0.594	0.001	5026	03/27/97	45	Orestimba Creek at State Hwy. 33 bridge
18	0.573	0.001	5027	05/03/96	45	Orestimba Creek above Crow Creek Drain
19	0.565	0.001	5027	04/24/97	45	Orestimba Creek above Crow Creek Drain
20	0.553	0.001	5028	04/23/97	45	Orestimba Creek at River Road (trib. to SJR)
21	0.551	0.001	5027	07/26/96	45	Orestimba Creek above Crow Creek Drain
22	0.532	0.001	5027	03/30/97	45	Orestimba Creek above Crow Creek Drain
23	0.531	0.001	5027	05/02/96	45	Orestimba Creek above Crow Creek Drain
24	0.509	0.001	5026	03/28/97	45	Orestimba Creek at State Hwy. 33 bridge
25	0.495	0.001	5026	03/24/97	45	Orestimba Creek at State Hwy. 33 bridge
26	0.485	0.001	5026	04/24/97	45	Orestimba Creek at State Hwy. 33 bridge
27	0.479	0.001	5028	08/23/96	45	Orestimba Creek at River Road (trib. to SJR)
28	0.463	0.001	5028	04/27/97	45	Orestimba Creek at River Road (trib. to SJR)
29	0.462	0.001	5027	04/25/97	45	Orestimba Creek above Crow Creek Drain
30	0.451	0.001	5028	04/28/97	45	Orestimba Creek at River Road (trib. to SJR)
31	0.44	0.001	5026	04/29/97	45	Orestimba Creek at State Hwy. 33 bridge
32	0.436	0.001	5028	03/29/97	45	Orestimba Creek at River Road (trib. to SJR)
33	0.426	0.001	5028	04/24/97	45	Orestimba Creek at River Road (trib. to SJR)
34	0.424	0.001	5028	05/30/96	45	Orestimba Creek at River Road (trib. to SJR)
35	0.421	0.001	5026	04/23/97	45	Orestimba Creek at State Hwy. 33 bridge
36	0.419	0.001	5026	04/28/97	45	Orestimba Creek at State Hwy. 33 bridge
37	0.418	0.001	5028	03/28/97	45	Orestimba Creek at River Road (trib. to SJR)
38	0.416	0.001	5027	07/28/96	45	Orestimba Creek above Crow Creek Drain
39	0.413	0.001	5028	03/23/97	45	Orestimba Creek at River Road (trib. to SJR)
40	0.396	0.001	5027	05/22/96	45	Orestimba Creek above Crow Creek Drain
41	0.387	0.001	5028	04/26/97	45	Orestimba Creek at River Road (trib. to SJR)
42	0.379	0.001	5028	03/27/97	45	Orestimba Creek at River Road (trib. to SJR)
43	0.371	0.001	5028	03/24/97	45	Orestimba Creek at River Road (trib. to SJR)
44	0.368	0.001	5027	03/25/97	45	Orestimba Creek above Crow Creek Drain
45	0.365	0.01	5019	02/10/92	35	Turlock Irrig. Dist. Drain #3 at Jennings Rd Bridge
46	0.364	0.001	5026	04/25/97	45	Orestimba Creek at State Hwy. 33 bridge
47	0.36	0.01	5028	07/30/91	35	Orestimba Creek at River Road (trib. to SJR)
48	0.358	0.001	5026	05/04/96	45	Orestimba Creek at State Hwy. 33 bridge
49	0.348	0.001	5026	03/29/97	45	Orestimba Creek at State Hwy. 33 bridge
50	0.324	0.001	5028	03/25/97	45	Orestimba Creek at River Road (trib. to SJR)
51	0.323	0.001	5026	05/12/96	45	Orestimba Creek at State Hwy. 33 bridge

rank	chlorpyrifc ug/L	LOQ ug/L	site code	date	study code	site description
52	0.323	0.001	5028	03/26/97	45	Orestimba Creek at River Road (trib. to SJR)
53	0.308	0.001	5027	05/04/96	45	Orestimba Creek above Crow Creek Drain
54	0.304	0.001	5027	04/23/97	45	Orestimba Creek above Crow Creek Drain
55	0.297	0.001	5026	03/25/97	45	Orestimba Creek at State Hwy. 33 bridge
56	0.285	0.01	5014	03/19/91	35	Ingram/Hospital Creek (trib. to SJR)
57	0.278	0.001	5026	07/27/96	45	Orestimba Creek at State Hwy. 33 bridge
58	0.271	0.001	5026	05/14/96	45	Orestimba Creek at State Hwy. 33 bridge
59	0.268	0.001	5028	03/15/97	45	Orestimba Creek at River Road (trib. to SJR)
60	0.266	0.001	5026	04/22/97	45	Orestimba Creek at State Hwy. 33 bridge
61	0.263	0.001	5028	09/11/96	45	Orestimba Creek at River Road (trib. to SJR)
62	0.263	0.001	5028	04/25/97	45	Orestimba Creek at River Road (trib. to SJR)
63	0.262	0.001	5027	05/20/96	45	Orestimba Creek above Crow Creek Drain
64	0.254	0.001	5028	08/21/96	45	Orestimba Creek at River Road (trib. to SJR)
65	0.253	0.001	5026	05/09/96	45	Orestimba Creek at State Hwy. 33 bridge
66	0.253	0.001	5028	08/04/96	45	Orestimba Creek at River Road (trib. to SJR)
67	0.246	0.001	5028	09/11/96	45	Orestimba Creek at River Road (trib. to SJR)
68	0.235	0.01	5025	03/19/91	35	Spanish Grant Drain (trib. to SJR)
69	0.23	0.05	5024	04/25/91	10	Turlock Irrig. Dist. Drain #5
70	0.23	0.001	5026	04/26/97	45	Orestimba Creek at State Hwy. 33 bridge
71	0.223	0.001	5026	05/10/96	45	Orestimba Creek at State Hwy. 33 bridge
72	0.22	0.001	5026	05/11/96	45	Orestimba Creek at State Hwy. 33 bridge
73	0.217	0.001	5027	03/31/97	45	Orestimba Creek above Crow Creek Drain
74	0.215	0.001	5028	09/20/96	45	Orestimba Creek at River Road (trib. to SJR)
75	0.21	0.05	2408	02/09/93	10	Newman Wasteway (trib. to SJR)
76	0.21	0.01	5024	04/26/91	35	Turlock Irrig. Dist. Drain #5
77	0.208	0.001	5027	08/11/96	45	Orestimba Creek above Crow Creek Drain
78	0.205	0.001	5026	05/13/96	45	Orestimba Creek at State Hwy. 33 bridge
79	0.201	0.001	5028	04/30/97	45	Orestimba Creek at River Road (trib. to SJR)
80	0.194	0.001	5028	03/21/97	45	Orestimba Creek at River Road (trib. to SJR)
81	0.192	0.001	5026	04/27/97	45	Orestimba Creek at State Hwy. 33 bridge
82	0.189	0.001	5028	04/22/97	45	Orestimba Creek at River Road (trib. to SJR)
83	0.186	0.001	5026	05/02/96	45	Orestimba Creek at State Hwy. 33 bridge
84	0.184	0.001	5028	03/22/97	45	Orestimba Creek at River Road (trib. to SJR)
85	0.178	0.001	5026	04/30/97	45	Orestimba Creek at State Hwy. 33 bridge
86	0.178	0.001	5028	09/12/96	45	Orestimba Creek at River Road (trib. to SJR)
87	0.178	0.001	5028	03/30/97	45	Orestimba Creek at River Road (trib. to SJR)
88	0.177	0.001	5026	03/31/97	45	Orestimba Creek at State Hwy. 33 bridge
89	0.17	0.001	5027	08/01/96	45	Orestimba Creek above Crow Creek Drain
90	0.169	0.001	5028	05/13/96	45	Orestimba Creek at River Road (trib. to SJR)
91	0.165	0.01	5014	09/06/91	35	Ingram/Hospital Creek (trib. to SJR)
92	0.165	0.001	5026	05/15/96	45	Orestimba Creek at State Hwy. 33 bridge
93	0.165	0.001	5028	04/29/97	45	Orestimba Creek at River Road (trib. to SJR)
94	0.164	0.001	5028	03/16/97	45	Orestimba Creek at River Road (trib. to SJR)
95	0.162	0.001	5028	05/15/96	45	Orestimba Creek at River Road (trib. to SJR)
96	0.158	0.001	5028	05/14/96	45	Orestimba Creek at River Road (trib. to SJR)
97	0.157	0.001	5028	04/30/97	45	Orestimba Creek at River Road (trib. to SJR)
98	0.154	0.001	5027	04/22/97	45	Orestimba Creek above Crow Creek Drain
99	0.154	0.001	5028	03/31/97	45	Orestimba Creek at River Road (trib. to SJR)
100	0.149	0.001	5026	05/03/96	45	Orestimba Creek at State Hwy. 33 bridge

Appendix 6. Co-occurrence of diazinon and chlorpyrifos by site.

Appendix 6. Co-occurrence of diazinon and chlorpyrifos by site

<u>*Strongly biased data. Co-occurrence data heavily dependent on LOQ of both analytes*</u>

<u>*==> see text*</u>

number samples positive for both	site code	site description
299	5028	Orestimba Creek at River Road (trib. to SJR)
220	5026	Orestimba Creek at State Hwy. 33 bridge
188	5027	Orestimba Creek above Crow Creek Drain
23	2407	Merced River at River Road Bridge near Newman
22	3415	Arcade Creek at Norwood
19	5015	San Joaquin River at Laird Park
18	2413	Salt Slough (trib. to SJR) at Highway 165
17	5014	Ingram/Hospital Creek (trib. to SJR)
17	5018	Del Puerto Creek (trib. to SJR)
16	5024	Turlock Irrig. Dist. Drain #5
15	5025	Spanish Grant Drain (trib. to SJR)
13	5019	Turlock Irrig. Dist. Drain #3 at Jennings Rd Bridge
9	3917	San Joaquin River near Vernalis
7	2402	Turlock Irrig. Drain #6, 200 yds W of Central Ave (trib to SJR)
6	2406	Merced River at Hatfield State Park
6	5702	Colusa Basin Drain at Rd. 99E, near Knights Landing
4	1306	Alamo River at Harris Street Bridge
4	5008	Dry Creek at Gallo Rd near Modesto
4	5029	San Joaquin River at Hills Ferry
3	1301	Alamo River at Outlet
3	1302	Alamo River at Albright Road (Nectarine Drain Area
3	2408	Newman Wasteway (trib. to SJR)
3	5016	Tuolumne River at Shiloh
2	1307	Alamo River at Worthington Road
2	3918	Stanislaus River at Caswell State Park
2	5004	Dry Creek at Claus Rd, Modesto
2	5017	Tuolumne River at Carpenter Rd Bridge
2	5023	San Joaquin River at West Main
1	1304	Alamo River downstream of Rose Drain
1	1305	Alamo River downstream of Holtville Main Drain
1	1308	Alamo River at Holtville WTP
1	2404	Highline Spillway (trib. to SJR)
1	2405	Livingston Spillway (trib. to SJR)
1	2409	San Joaquin River at Fremont Ford
1	2410	Los Banos Creek (trib. to SJR)
1	2412	Mud Slough (trib. to SJR)
1	3907	San Joaquin River at Bowman Rd
1	3916	Bishop Cut at Eight Mile Rd (in Delta)
1	5002	San Joaquin River at Maze Blvd.
1	5007	Tuolumne River at Modesto
1	5011	Oakdale Irr Dist at Ellenwood Rd nr Waterford
1	5012	Turlock Irr Dist Hickman Spillway
1	5022	Turlock Irr Dist Ceres Main Spillway
1	5110	Sacramento Outfall at DWR PP on Sacramento Road

Appendix 7. Diazinon monitoring results for DPR's 1997 - 2001 dormant spray monitoring studies.

Appendix 7. Diazinon results from DPR's dormant spray monitoring studies (1997 - 2001), non-detects = 0

sample date	diazinon ug/L	LOQ ug/L	site code	study code	
12/2/96	0	0.04	5701	33	Sacramento River - 2 sites: 5701 and 3418
12/4/96	0	0.04	5701	33	
12/6/96	0	0.04	5701	33	
1/20/97	0	0.04	5701	33	
1/22/97	0	0.04	5701	33	
1/24/97	0.061	0.04	5701	33	
1/27/97	0.061	0.04	5701	33	
1/29/97	0.065	0.04	5701	33	
1/31/97	0.064	0.04	5701	33	
2/3/97	0	0.04	5701	33	
2/5/97	0	0.04	5701	33	
2/7/97	0	0.04	5701	33	
2/10/97	0	0.04	5701	33	
2/12/97	0	0.04	5701	33	
2/14/97	0	0.04	5701	33	
2/17/97	0	0.04	5701	33	
2/19/97	0	0.04	5701	33	
2/21/97	0	0.04	5701	33	
2/24/97	0	0.04	5701	33	
2/26/97	0	0.04	5701	33	
2/28/97	0	0.04	5701	33	
3/3/97	0	0.04	5701	33	
3/5/97	0	0.04	5701	33	
3/7/97	0	0.04	5701	33	
12/1/97	0	0.04	3418	37	
12/3/97	0	0.04	3418	37	
12/5/97	0	0.04	3418	37	
1/5/98	0	0.04	3418	37	
1/7/98	0	0.04	3418	37	
1/9/98	0	0.04	3418	37	
1/12/98	0	0.04	3418	37	
1/14/98	0	0.04	3418	37	
1/16/98	0	0.04	3418	37	
1/19/98	0	0.04	3418	37	
1/21/98	0	0.04	3418	37	
1/23/98	0	0.04	3418	37	
1/26/98	0	0.04	3418	37	
1/28/98	0	0.04	3418	37	
1/30/98	0.132	0.04	3418	37	
2/2/98	0.074	0.04	3418	37	
2/4/98	0	0.04	3418	37	
2/6/98	0.088	0.04	3418	37	
2/9/98	0.066	0.04	3418	37	
2/11/98	0.058	0.04	3418	37	
2/13/98	0.067	0.04	3418	37	
2/16/98	0.09	0.04	3418	37	
2/18/98	0.171	0.04	3418	37	
2/20/98	0.059	0.04	3418	37	
2/23/98	0.091	0.04	3418	37	
2/25/98	0.073	0.04	3418	37	
2/27/98	0.074	0.04	3418	37	

sample date	diazinon ug/L	LOQ ug/L	site code	study code	
3/2/98	0	0.04	3418	37	Sacramento River - 2 sites: 5701 and 3418
3/4/98	0	0.04	3418	37	
3/6/98	0	0.04	3418	37	
12/7/98	0	0.04	3418	57	
12/9/98	0	0.04	3418	57	
12/11/98	0	0.04	3418	57	
1/4/99	0	0.04	3418	57	
1/6/99	0	0.04	3418	57	
1/8/99	0	0.04	3418	57	
1/11/99	0	0.04	3418	57	
1/13/99	0	0.04	3418	57	
1/15/99	0	0.04	3418	57	
1/18/99	0	0.04	3418	57	
1/20/99	0	0.04	3418	57	
1/22/99	0	0.04	3418	57	
1/25/99	0	0.04	3418	57	
1/27/99	0	0.04	3418	57	
1/29/99	0	0.04	3418	57	
2/1/99	0	0.04	3418	57	
2/3/99	0	0.04	3418	57	
2/5/99	0	0.04	3418	57	
2/8/99	0	0.04	3418	57	
2/10/99	0	0.04	3418	57	
2/12/99	0	0.04	3418	57	
2/15/99	0	0.04	3418	57	
2/17/99	0	0.04	3418	57	
2/19/99	0	0.04	3418	57	
2/22/99	0	0.04	3418	57	
2/24/99	0	0.04	3418	57	
2/26/99	0	0.04	3418	57	
3/1/99	0	0.04	3418	57	
3/3/99	0	0.04	3418	57	
3/5/99	0	0.04	3418	57	
12/6/99	0	0.04	3418	63	
12/8/99	0	0.04	3418	63	
12/10/99	0	0.04	3418	63	
1/3/00	0	0.04	3418	63	
1/5/00	0	0.04	3418	63	
1/7/00	0	0.04	3418	63	
1/10/00	0	0.04	3418	63	
1/12/00	0	0.04	3418	63	
1/14/00	0	0.04	3418	63	
1/17/00	0	0.04	3418	63	
1/19/00	0	0.04	3418	63	
1/21/00	0	0.04	3418	63	
1/24/00	0	0.04	3418	63	
1/26/00	0	0.04	3418	63	
1/28/00	0	0.04	3418	63	
1/31/00	0	0.04	3418	63	
2/2/00	0.057	0.04	3418	63	
2/4/00	0	0.04	3418	63	
2/7/00	0	0.04	3418	63	
2/9/00	0	0.04	3418	63	

sample date	diazinon ug/L	LOQ ug/L	site code	study code	
2/11/00	0	0.04	3418	63	Sacramento River - 2 sites: 5701 and 3418
2/14/00	0	0.04	3418	63	
2/16/00	0.057	0.04	3418	63	
2/18/00	0	0.04	3418	63	
2/20/00	0	0.04	3418	63	
2/21/00	0	0.04	3418	63	
2/23/00	0	0.04	3418	63	
2/25/00	0	0.04	3418	63	
3/1/00	0	0.04	3418	63	
3/3/00	0	0.04	3418	63	
3/6/00	0	0.04	3418	63	
3/8/00	0	0.04	3418	63	
3/10/00	0	0.04	3418	63	
12/4/00	0	0.04	3418	99	
12/6/00	0	0.04	3418	99	
12/8/00	0	0.04	3418	99	
1/2/01	0	0.04	3418	99	
1/4/01	0	0.04	3418	99	
1/8/01	0	0.04	3418	99	
1/10/01	0	0.04	3418	99	
1/12/01	0	0.04	3418	99	
1/15/01	0	0.04	3418	99	
1/17/01	0	0.04	3418	99	
1/19/01	0.029	0.04	3418	99	
1/22/01	0	0.04	3418	99	
1/24/01	0	0.04	3418	99	
1/26/01	0	0.04	3418	99	
1/29/01	0	0.04	3418	99	
1/31/01	0	0.04	3418	99	
2/2/01	0	0.04	3418	99	
2/5/01	0	0.04	3418	99	
2/7/01	0	0.04	3418	99	
2/9/01	0	0.04	3418	99	
2/12/01	0	0.04	3418	99	
2/14/01	0	0.04	3418	99	
2/16/01	0	0.04	3418	99	
2/19/01	0	0.04	3418	99	
2/21/01	0	0.04	3418	99	
2/23/01	0	0.04	3418	99	
2/26/01	0	0.04	3418	99	
2/28/01	0	0.04	3418	99	
3/2/01	0	0.04	3418	99	
3/5/01	0	0.04	3418	99	
3/7/01	0	0.04	3418	99	
3/9/01	0	0.04	3418	99	
3/12/01	0	0.04	3418	99	
3/14/01	0	0.04	3418	99	

sample date	diazinon ug/L	LOQ ug/L	site code	study code
12/2/96	0	0.04	3917	32
12/4/96	0	0.04	3917	32
12/6/96	0	0.04	3917	32
1/20/97	0	0.04	3917	32
1/22/97	0	0.04	3917	32
1/24/97	0.07	0.04	3917	32
1/27/97	0.051	0.04	3917	32
1/29/97	0.05	0.04	3917	32
1/31/97	0	0.04	3917	32
2/3/97	0	0.04	3917	32
2/5/97	0	0.04	3917	32
2/7/97	0	0.04	3917	32
2/10/97	0	0.04	3917	32
2/12/97	0	0.04	3917	32
2/14/97	0	0.04	3917	32
2/17/97	0	0.04	3917	32
2/19/97	0	0.04	3917	32
2/21/97	0	0.04	3917	32
2/24/97	0	0.04	3917	32
2/26/97	0	0.04	3917	32
2/28/97	0	0.04	3917	32
3/3/97	0	0.04	3917	32
3/5/97	0	0.04	3917	32
3/7/97	0	0.04	3917	32
12/1/97	0	0.04	3917	38
12/3/97	0	0.04	3917	38
12/5/97	0	0.04	3917	38
1/5/98	0	0.04	3917	38
1/7/98	0.04	0.04	3917	38
1/9/98	0	0.04	3917	38
1/12/98	0.063	0.04	3917	38
1/14/98	0.086	0.04	3917	38
1/16/98	0.102	0.04	3917	38
1/19/98	0	0.04	3917	38
1/21/98	0	0.04	3917	38
1/23/98	0	0.04	3917	38
1/26/98	0	0.04	3917	38
1/28/98	0	0.04	3917	38
1/30/98	0.0815	0.04	3917	38
2/2/98	0.047	0.04	3917	38
2/4/98	0.093	0.04	3917	38
2/6/98	0.067	0.04	3917	38
2/9/98	0.048	0.04	3917	38
2/11/98	0.042	0.04	3917	38
2/13/98	0	0.04	3917	38
2/16/98	0	0.04	3917	38
2/18/98	0	0.04	3917	38
2/20/98	0	0.04	3917	38
2/23/98	0	0.04	3917	38
2/25/98	0	0.04	3917	38
2/27/98	0	0.04	3917	38
3/2/98	0	0.04	3917	38
3/4/98	0	0.04	3917	38

San Joaquin River near Vernalis - site 3917

sample date	diazinon ug/L	LOQ ug/L	site code	study code	
3/6/98	0	0.04	3917	38	San Joaquin River near Vernalis - site 3917
12/7/98	0	0.04	3917	58	
12/9/98	0	0.04	3917	58	
12/11/98	0	0.04	3917	58	
1/4/99	0	0.04	3917	58	
1/6/99	0	0.04	3917	58	
1/8/99	0	0.04	3917	58	
1/11/99	0	0.04	3917	58	
1/13/99	0	0.04	3917	58	
1/15/99	0	0.04	3917	58	
1/18/99	0	0.04	3917	58	
1/20/99	0.144	0.04	3917	58	
1/22/99	0.09	0.04	3917	58	
1/25/99	0	0.04	3917	58	
1/27/99	0	0.04	3917	58	
1/29/99	0	0.04	3917	58	
2/1/99	0	0.04	3917	58	
2/3/99	0	0.04	3917	58	
2/5/99	0	0.04	3917	58	
2/8/99	0	0.04	3917	58	
2/10/99	0.053	0.04	3917	58	
2/12/99	0	0.04	3917	58	
2/15/99	0	0.04	3917	58	
2/17/99	0	0.04	3917	58	
2/19/99	0	0.04	3917	58	
2/22/99	0	0.04	3917	58	
2/24/99	0	0.04	3917	58	
2/26/99	0	0.04	3917	58	
3/1/99	0	0.04	3917	58	
3/3/99	0	0.04	3917	58	
3/5/99	0	0.04	3917	58	
12/6/99	0	0.04	3917	62	
12/8/99	0	0.04	3917	62	
12/10/99	0	0.04	3917	62	
1/3/00	0	0.04	3917	62	
1/5/00	0	0.04	3917	62	
1/7/00	0	0.04	3917	62	
1/10/00	0	0.04	3917	62	
1/12/00	0	0.04	3917	62	
1/14/00	0	0.04	3917	62	
1/17/00	0	0.04	3917	62	
1/19/00	0	0.04	3917	62	
1/21/00	0.1	0.04	3917	62	
1/24/00	0.045	0.04	3917	62	
1/26/00	0.051	0.04	3917	62	
1/28/00	0	0.04	3917	62	
1/31/00	0	0.04	3917	62	
2/2/00	0	0.04	3917	62	
2/4/00	0	0.04	3917	62	
2/7/00	0	0.04	3917	62	
2/9/00	0	0.04	3917	62	
2/11/00	0	0.04	3917	62	
2/14/00	0	0.04	3917	62	

sample date	diazinon ug/L	LOQ ug/L	site code	study code
2/16/00	0	0.04	3917	62
2/18/00	0	0.04	3917	62
2/21/00	0	0.04	3917	62
2/23/00	0	0.04	3917	62
2/25/00	0	0.04	3917	62
2/28/00	0	0.04	3917	62
3/1/00	0	0.04	3917	62
3/3/00	0	0.04	3917	62
12/4/00	0	0.04	3917	00
12/6/00	0	0.04	3917	00
12/8/00	0	0.04	3917	00
1/2/01	0	0.04	3917	00
1/4/01	0	0.04	3917	00
1/8/01	0	0.04	3917	00
1/10/01	0	0.04	3917	00
1/12/01	0.051	0.04	3917	00
1/15/01	0	0.04	3917	00
1/17/01	0	0.04	3917	00
1/19/01	0	0.04	3917	00
1/22/01	0	0.04	3917	00
1/24/01	0	0.04	3917	00
1/26/01	0	0.04	3917	00
1/29/01	0.131	0.04	3917	00
1/31/01	0.054	0.04	3917	00
2/2/01	0	0.04	3917	00
2/5/01	0	0.04	3917	00
2/7/01	0	0.04	3917	00
2/9/01	0	0.04	3917	00
2/12/01	0.044	0.04	3917	00
2/14/01	0	0.04	3917	00
2/16/01	0	0.04	3917	00
2/19/01	0	0.04	3917	00
2/21/01	0	0.04	3917	00
2/23/01	0	0.04	3917	00
2/26/01	0	0.04	3917	00
2/28/01	0	0.04	3917	00
3/2/01	0	0.04	3917	00
3/5/01	0	0.04	3917	00
3/7/01	0	0.04	3917	00
3/9/01	0	0.04	3917	00

San Joaquin River near Vernalis - site 3917

sample date	diazinon ug/L	LOQ ug/L	site code	study code	
12/2/96	0	0.04	5028	32	Orestimba Creek at River Road - site 5028
12/4/96	0	0.04	5028	32	
1/20/97	0	0.04	5028	32	
1/22/97	0	0.04	5028	32	
1/27/97	0	0.04	5028	32	
1/29/97	0	0.04	5028	32	
2/3/97	0	0.04	5028	32	
2/5/97	0	0.04	5028	32	
2/10/97	0	0.04	5028	32	
2/12/97	0.092	0.04	5028	32	
2/17/97	0.04	0.04	5028	32	
2/19/97	0.076	0.04	5028	32	
2/26/97	0	0.04	5028	32	
3/3/97	0	0.04	5028	32	
3/5/97	0	0.04	5028	32	
12/1/97	0	0.04	5028	38	
12/3/97	0	0.04	5028	38	
1/12/98	0.139	0.04	5028	38	
1/14/98	0	0.04	5028	38	
1/19/98	0	0.04	5028	38	
1/21/98	0	0.04	5028	38	
1/26/98	0	0.04	5028	38	
1/28/98	0	0.04	5028	38	
2/2/98	0.11	0.04	5028	38	
2/4/98	0.059	0.04	5028	38	
2/9/98	0	0.04	5028	38	
2/11/98	0	0.04	5028	38	
2/16/98	0	0.04	5028	38	
2/18/98	0	0.04	5028	38	
2/23/98	0	0.04	5028	38	
2/25/98	0	0.04	5028	38	
3/2/98	0	0.04	5028	38	
3/4/98	0	0.04	5028	38	
12/7/98	0	0.04	5028	58	
12/9/98	0	0.04	5028	58	
1/4/99	0	0.04	5028	58	
1/6/99	0	0.04	5028	58	
1/11/99	0	0.04	5028	58	
1/13/99	0	0.04	5028	58	
1/18/99	0	0.04	5028	58	
1/20/99	0	0.04	5028	58	
1/25/99	0	0.04	5028	58	
1/27/99	0	0.04	5028	58	
2/1/99	0	0.04	5028	58	
2/3/99	0	0.04	5028	58	
2/8/99	0	0.04	5028	58	
2/10/99	0	0.04	5028	58	
2/15/99	0	0.04	5028	58	
2/17/99	0	0.04	5028	58	
2/22/99	0	0.04	5028	58	
2/24/99	0	0.04	5028	58	
3/1/99	0	0.04	5028	58	
3/3/99	0	0.04	5028	58	

sample date	diazinon ug/L	LOQ ug/L	site code	study code	
12/6/99	0	0.04	5028	62	Orestimba Creek at River Road - site 5028
12/8/99	0	0.04	5028	62	
1/3/00	0	0.04	5028	62	
1/5/00	0	0.04	5028	62	
1/10/00	0	0.04	5028	62	
1/12/00	0.161	0.04	5028	62	
1/17/00	0	0.04	5028	62	
1/19/00	0.043	0.04	5028	62	
1/24/00	0.069	0.04	5028	62	
1/26/00	0.051	0.04	5028	62	
1/31/00	0	0.04	5028	62	
2/2/00	0	0.04	5028	62	
2/7/00	0	0.04	5028	62	
2/9/00	0	0.04	5028	62	
2/14/00	0	0.04	5028	62	
2/16/00	0	0.04	5028	62	
2/21/00	0	0.04	5028	62	
2/23/00	0	0.04	5028	62	
2/28/00	0	0.04	5028	62	
3/1/00	0	0.04	5028	62	
12/4/00	0	0.04	5028	00	
12/6/00	0	0.04	5028	00	
1/2/01	0	0.04	5028	00	
1/4/01	0.042	0.04	5028	00	
1/8/01	0	0.04	5028	00	
1/10/01	0	0.04	5028	00	
1/15/01	0	0.04	5028	00	
1/17/01	0	0.04	5028	00	
1/22/01	0	0.04	5028	00	
1/24/01	0	0.04	5028	00	
1/29/01	0	0.04	5028	00	
1/31/01	0	0.04	5028	00	
2/5/01	0	0.04	5028	00	
2/7/01	0	0.04	5028	00	
2/12/01	0	0.04	5028	00	
2/14/01	0	0.04	5028	00	
2/19/01	0	0.04	5028	00	
2/21/01	0	0.04	5028	00	
2/26/01	0	0.04	5028	00	
2/28/01	0	0.04	5028	00	
3/5/01	0	0.04	5028	00	
3/7/01	0	0.04	5028	00	

sample date	diazinon ug/L	LOQ ug/L	site code	study code	
12/2/96	0	0.04	5104	33	Sutter bypass - two sites: 5104 and 5106
12/4/96	0	0.04	5104	33	
1/20/97	0	0.04	5106	33	
1/22/97	0	0.04	5106	33	
1/27/97	0.086	0.04	5106	33	
1/29/97	0.063	0.04	5106	33	
2/3/97	0	0.04	5106	33	
2/5/97	0	0.04	5106	33	
2/10/97	0	0.04	5106	33	
2/12/97	0	0.04	5106	33	
2/17/97	0.056	0.04	5104	33	
2/19/97	0.052	0.04	5104	33	
2/24/97	0.047	0.04	5104	33	
2/26/97	0.041	0.04	5104	33	
3/3/97	0.04	0.04	5104	33	
3/5/97	0	0.04	5104	33	
12/1/97	0	0.04	5104	37	
12/3/97	0	0.04	5104	37	
1/5/98	0.063	0.04	5104	37	
1/7/98	0.088	0.04	5104	37	
1/12/98	0	0.04	5104	37	
1/14/98	0.089	0.04	5106	37	
1/19/98	0	0.04	5106	37	
1/21/98	0	0.04	5106	37	
1/26/98	0	0.04	5106	37	
1/28/98	0.104	0.04	5106	37	
2/2/98	0	0.04	5106	37	
2/4/98	0.073	0.04	5106	37	
2/9/98	0.043	0.04	5106	37	
2/11/98	0	0.04	5106	37	
2/16/98	0	0.04	5106	37	
2/18/98	0	0.04	5106	37	
2/23/98	0	0.04	5106	37	
2/25/98	0	0.04	5106	37	
3/2/98	0	0.04	5106	37	
3/4/98	0	0.04	5106	37	
12/7/98	0	0.04	5106	57	
12/9/98	0	0.04	5106	57	
1/4/99	0	0.04	5104	57	
1/6/99	0	0.04	5104	57	
1/11/99	0.072	0.04	5104	57	
1/13/99	0.074	0.04	5104	57	
1/18/99	0.11	0.04	5104	57	
1/20/99	0.0765	0.04	5106	57	
1/25/99	0.041	0.04	5106	57	
1/27/99	0.042	0.04	5106	57	
2/1/99	0.076	0.04	5106	57	
2/3/99	0.085	0.04	5104	57	
2/8/99	0.065	0.04	5106	57	
2/10/99	0	0.04	5106	57	
2/15/99	0	0.04	5106	57	
2/17/99	0	0.04	5106	57	
2/22/99	0	0.04	5106	57	

sample date	diazinon ug/L	LOQ ug/L	site code	study code
2/24/99	0	0.04	5106	57
3/1/99	0	0.04	5106	57
3/3/99	0	0.04	5106	57
12/6/99	0	0.04	5104	63
12/8/99	0	0.04	5104	63
1/3/00	0	0.04	5104	63
1/5/00	0	0.04	5104	63
1/10/00	0	0.04	5104	63
1/12/00	0	0.04	5104	63
1/17/00	0	0.04	5104	63
1/19/00	0	0.04	5104	63
1/25/00	0	0.04	5104	63
1/26/00	0	0.04	5104	63
1/31/00	0.043	0.04	5104	63
2/2/00	0.093	0.04	5104	63
2/7/00	0.053	0.04	5104	63
2/9/00	0.041	0.04	5104	63
2/14/00	0	0.04	5106	63
2/16/00	0	0.04	5106	63
2/21/00	0	0.04	5106	63
2/23/00	0	0.04	5106	63
2/28/00	0	0.04	5106	63
3/1/00	0	0.04	5106	63
3/6/00	0	0.04	5106	63
3/8/00	0	0.04	5106	63
12/4/00	0	0.04	5104	99
12/6/00	0	0.04	5104	99
1/2/01	0	0.04	5104	99
1/4/01	0	0.04	5104	99
1/8/01	0	0.04	5104	99
1/10/01	0	0.04	5104	99
1/15/01	0	0.04	5104	99
1/17/01	0	0.04	5104	99
1/22/01	0	0.04	5104	99
1/24/01	0	0.04	5104	99
1/29/01	0.058	0.04	5104	99
1/31/01	0.045	0.04	5104	99
2/5/01	0.049	0.04	5104	99
2/7/01	0.04	0.04	5104	99
2/12/01	0	0.04	5104	99
2/14/01	0.107	0.04	5104	99
2/19/01	0	0.04	5104	99
2/21/01	0	0.04	5104	99
2/26/01	0.132	0.04	5104	99
2/28/01	0.056	0.04	5104	99
3/5/01	0.05	0.04	5104	99
3/7/01	0.052	0.04	5104	99
3/12/01	0	0.04	5104	99
3/14/01	0	0.04	5104	99

Sutter bypass - two sites: 5104 and 5106

sample date	diazinon ug/L	LOQ ug/L	site code	study code	
12/7/98	0	0.04	5113	57	Wadsworth Canal - site code 5113
12/9/98	0	0.04	5113	57	
1/4/99	0.124	0.04	5113	57	
1/6/99	0.228	0.04	5113	57	
1/11/99	0.216	0.04	5113	57	
1/13/99	0.163	0.04	5113	57	
1/18/99	0.321	0.04	5113	57	
1/20/99	0.318	0.04	5113	57	
1/25/99	0.155	0.04	5113	57	
1/27/99	0.211	0.04	5113	57	
2/1/99	1.11	0.04	5113	57	
2/3/99	0.154	0.04	5113	57	
2/8/99	1.61	0.04	5113	57	
2/10/99	1.02	0.04	5113	57	
2/15/99	0.132	0.04	5113	57	
2/17/99	1.27	0.04	5113	57	
2/22/99	0.177	0.04	5113	57	
2/24/99	0.082	0.04	5113	57	
3/1/99	0.044	0.04	5113	57	
3/3/99	0	0.04	5113	57	
12/6/99	0	0.04	5113	63	
12/8/99	0	0.04	5113	63	
1/3/00	0	0.04	5113	63	
1/5/00	0	0.04	5113	63	
1/10/00	0	0.04	5113	63	
1/12/00	0	0.04	5113	63	
1/17/00	0	0.04	5113	63	
1/19/00	0	0.04	5113	63	
1/24/00	0.042	0.04	5113	63	
1/26/00	0.054	0.04	5113	63	
1/31/00	2.74	0.04	5113	63	
2/2/00	0.504	0.04	5113	63	
2/7/00	0.175	0.04	5113	63	
2/9/00	0.193	0.04	5113	63	
2/14/00	1.738	0.04	5113	63	
2/16/00	0.541	0.04	5113	63	
2/21/00	0.34	0.04	5113	63	
2/23/00	0.568	0.04	5113	63	
2/28/00	0.291	0.04	5113	63	
3/1/00	0.091	0.04	5113	63	
3/6/00	0.113	0.04	5113	63	
3/8/00	0	0.04	5113	63	
12/4/00	0	0.04	5113	99	
12/6/00	0	0.04	5113	99	
1/2/01	0.059	0.04	5113	99	
1/4/01	0.053	0.04	5113	99	
1/8/01	1.32	0.04	5113	99	
1/10/01	0.085	0.04	5113	99	
1/15/01	0.067	0.04	5113	99	
1/17/01	0.042	0.04	5113	99	
1/22/01	0.04	0.04	5113	99	
1/24/01	0.185	0.04	5113	99	
1/29/01	0.065	0.04	5113	99	

sample date	diazinon ug/L	LOQ ug/L	site code	study code	
1/31/01	0.049	0.04	5113	99	Wadsworth Canal - site code 5113
2/5/01	0	0.04	5113	99	
2/7/01	0	0.04	5113	99	
2/12/01	0.536	0.04	5113	99	
2/14/01	0.164	0.04	5113	99	
2/19/01	0.119	0.04	5113	99	
2/21/01	0.154	0.04	5113	99	
2/26/01	0.289	0.04	5113	99	
2/28/01	0.049	0.04	5113	99	
3/5/01	0.393	0.04	5113	99	
3/7/01	0.064	0.04	5113	99	
3/12/01	0	0.04	5113	99	
3/14/01	0.067	0.04	5113	99	

Appendix 8. Description of sampling sites: county, meridian/township/range/section coordinates and description.

Appendix 8. List of locations sampled (MTRS is the baseline meridian/township/range/section designation according to the Survey of Public Lands). The MTRS describes the geographic position of the one-square mile section of land containing the sampling location.

location code	county	MTRS	description
0401	Butte	M17N01E02	Main Drainage Canal at Colusa Hwy (trib to Cherokee Canal)
0601	Colusa	M13N01W10	Clarks Ditch, trib. to Colusa Basin Drain
0604	Colusa	M16N01W29	Sacramento River at Colusa, 60 ft. downstream from highway bridge
0704	Contra Costa	M02N02E25	Marsh Creek at Cypress Rd bridge (trib to western Delta)
1101	Glenn	M19N01W32	Sacramento River at Butte City at Hwy 162 bridge
1301	Imperial	S11S13E23	Alamo River at Outlet
1302	Imperial	S12S14E29	Alamo River at Albright Road (Nectarine Drain Area
1303	Imperial	S13S15E19	Alamo River at Shank Road (Magnolia Drain Area
1304	Imperial	S14S15E06	Alamo River downstream of Rose Drain
1305	Imperial	S14S15E18	Alamo River downstream of Holtville Main Drain
1306	Imperial	S14S15E32	Alamo River at Harris Street Bridge
1307	Imperial	S15S15E16	Alamo River at Worthington Road
1308	Imperial	S15S15E21	Alamo River at Holtville WTP
1309	Imperial	S15S15E36	Alamo River at Holtville
1320	Imperial	S16S16E18	Alamo River downstream of Verde Drain
1321	Imperial	S17S15E18	Alamo River at All American Canal
2401	Merced	M05S12E36	Merced River at Oakdale Road
2402	Merced	M06S09E22	Turlock Irrig. Drain #6, 200 yds W of Central Ave (trib to SJR)
2403	Merced	M06S09E36	Stevinson Spillway (trib. to SJR)
2404	Merced	M06S10E25	Highline Spillway (trib. to SJR)
2405	Merced	M06S11E24	Livingston Spillway (trib. to SJR)
2406	Merced	M07S09E03	Merced River at Hatfield State Park
2407	Merced	M07S09E04	Merced River at River Road Bridge near Newman
2408	Merced	M07S09E16	Newman Wasteway (trib. to SJR)
2409	Merced	M07S09E24	San Joaquin River at Fremont Ford
2410	Merced	M07S09E35	Los Banos Creek (trib. to SJR)
2411	Merced	M07S10E26	San Joaquin River near Stevinson
2412	Merced	M07S10E31	Mud Slough (trib. to SJR)
2413	Merced	M08S10E10	Salt Slough (trib. to SJR) at Highway 165
2701	Monterey	M13S02E18	Salinas Lagoon
2702	Monterey	M16S04E10	Salinas River at Chualar River Rd. bridge
2703	Monterey	M17S05E06	Salinas River at Gonzales River Rd. bridge
3405	Sacramento	M07N04E24	Sacramento River at Freeport where stormwater pumping facility Sump 3 discharges
3413	Sacramento	M09N04E35	Sacramento River at I Street Bridge
3415	Sacramento	M09N05E13	Arcade Creek at Norwood
3418	Sacramento	M10N03E34	Sacramento River at Alamar Marina Dock, 9 mi below confluence of Feather River
3903	San Joaquin	M01N06E11	French Camp Slough at Manthey Bridge

location code	county	MTRS	description
3905	San Joaquin	M01S05E28	Paradise Cut north of MacArthur Rd and Delta Ave (north of Tracy, inside Delta)
3906	San Joaquin	M01S05E29	Old River at Tracy Road (inside Delta)
3907	San Joaquin	M01S06E09	San Joaquin River at Bowman Rd
3908	San Joaquin	M01S06E30	Old River off Cohen Road
3909	San Joaquin	M01S07E10	Lone Tree Creek at Austin Rd trib to French Camp Slough
3910	San Joaquin	M02N05E03	Bishop Tract Main Drain (in Delta)
3916	San Joaquin	M03N05E34	Bishop Cut at Eight Mile Rd (in Delta)
3917	San Joaquin	M03S06E13	San Joaquin River near Vernalis
3918	San Joaquin	M03S07E09	Stanislaus River at Caswell State Park
3919	San Joaquin	M04N05E34	Mokelumne River at New Hope Rd Bridge (in Delta)
4805	Solano	M05N02W17	Ledgewood Creek in City of Fairfield
4806	Solano	M06N01W20	Ulatis Creek at Brown Road
4902	Sonoma	M08N10W26	Russian River at Hacienda Bridge
4903	Sonoma	M08N10W28	Russian River at Midway Beach
5001	Stanislaus	M02S08E29	Stanislaus River at Ripon
5002	Stanislaus	M03S07E29	San Joaquin River at Maze Blvd.
5004	Stanislaus	M03S09E24	Dry Creek at Claus Rd, Modesto
5007	Stanislaus	M03S09E33	Tuolumne River at Modesto
5008	Stanislaus	M03S09E33	Dry Creek at Gallo Rd near Modesto
5010	Stanislaus	M03S11E13	Dry Creek at Leask Bridge nr Waterford
5011	Stanislaus	M03S11E20	Oakdale Irr Dist at Ellenwood Rd nr Waterford
5012	Stanislaus	M03S11E34	Turlock Irr Dist Hickman Spillway
5013	Stanislaus	M03S12E35	Tuolumne River at Roberts Ferry Bridge
5014	Stanislaus	M04S07E04	Ingram/Hospital Creek (trib. to SJR)
5015	Stanislaus	M04S07E25	San Joaquin River at Laird Park
5016	Stanislaus	M04S08E07	Tuolumne River at Shiloh
5017	Stanislaus	M04S08E12	Tuolumne River at Carpenter Rd Bridge
5018	Stanislaus	M04S08E31	Del Puerto Creek (trib. to SJR)
5019	Stanislaus	M04S08E34	Turlock Irrig. Dist. Drain #3 at Jennings Rd Bridge
5020	Stanislaus	M04S09E02	Tuolumne River at Mitchell Rd Bridge
5022	Stanislaus	M04S09E12	Turlock Irr Dist Ceres Main Spillway
5023	Stanislaus	M05S08E16	San Joaquin River at West Main
5024	Stanislaus	M05S09E30	Turlock Irrig. Dist. Drain #5
5025	Stanislaus	M06S08E01	Spanish Grant Drain (trib. to SJR)
5026	Stanislaus	M06S08E26	Orestimba Creek at State Hwy. 33 bridge
5027	Stanislaus	M06S08E35	Orestimba Creek above Crow Creek Drain
5028	Stanislaus	M06S09E18	Orestimba Creek at River Road (trib. to SJR)
5029	Stanislaus	M07S09E04	San Joaquin River at Hills Ferry
5103	Sutter	M11N03E20	Sacramento Slough near Karnak
5104	Sutter	M11N03E21	Sutter Bypass at Karnak Pumping Sta.
5105	Sutter	M11N03E36	Sacramento River 2.5 mi downstream of confluence of Sacramento and Feather rivers

location code	county	MTRS	description
5106	Sutter	M12N03E09	Sutter Bypass at Kirkville Road
5107	Sutter	M12N03E14	Feather River near Nicolaus at Hwy 99 Bridge
5109	Sutter	M13N03E31	Gilsizer Slough at G. Washington Rd (trib to Butte Slough)
5110	Sutter	M13N03E33	Sacramento Outfall at DWR PP on Sacramento Road
5111	Sutter	M14N02E26	Obanion Outfall at DWR PP on Obanion Road
5112	Sutter	M14N03E11	Feather River near Olivehurst at Lee Rd and Garden Hwy
5113	Sutter	M15N02E28	Wadsworth Canal at Franklin Rd
5115	Sutter	M16N01E31	Butte Slough at Lower Pass Road
5201	Tehama	M24N02W28	Sacramento River at Vina at Woodson Bridge
5701	Yolo	M09N04E33	Sacramento River at Bryte
5702	Yolo	M11N02E08	Colusa Basin Drain at Rd. 99E, near Knights Landing
5801	Yuba	M13N04E17	Bear River at Berry Road
5802	Yuba	M15N03E14	Jack Slough at Marysville
5803	Yuba	M15N03E23	Feather River at Yuba City
5804	Yuba	M15N04E13	Yuba River at Marysville
5805	Yuba	M17N03E26	Honcut Creek at Chandler Road